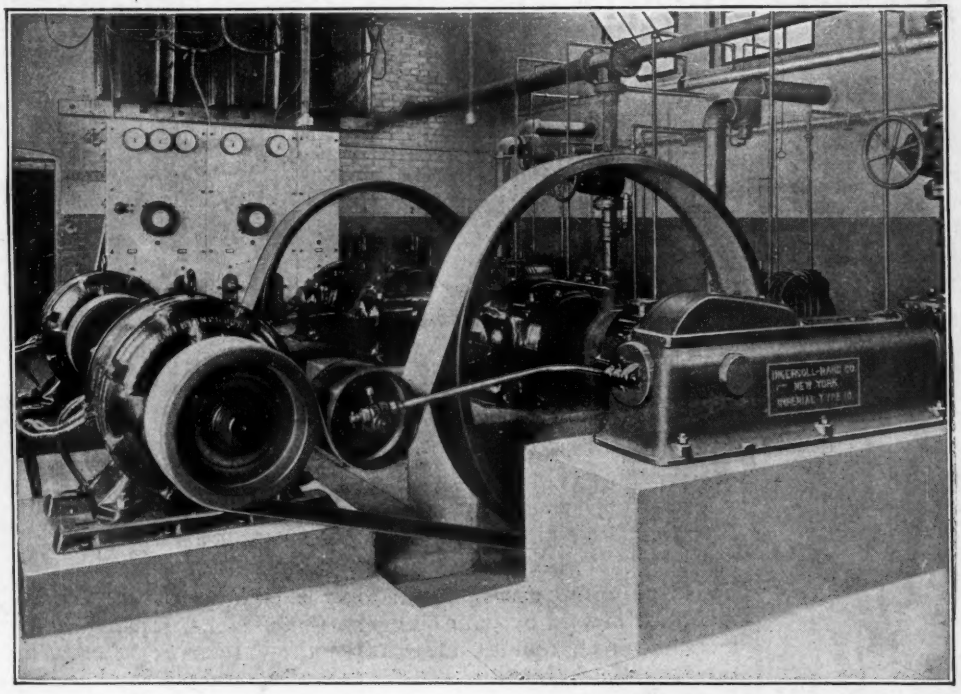
COMPRESSED AIR MAGAZINE

DEVOTED TO THE USEFUL APPLICATIONS OF COMPRESSED AIR

Vol. xxiii JUNE, 1918 No. 6



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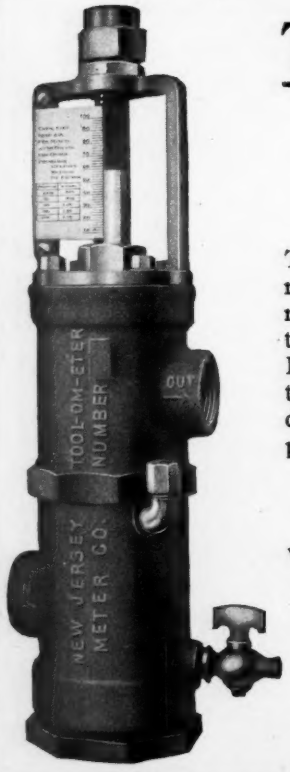

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COMPRESSED AIR MAGAZINE

EVERYTHING PNEUMATIC

Vol. xxiii JUNE, 1918 No. 6

VENTILATING THE BIG HIGHWAY TUNNEL

The proposed highway tunnel to be built under the Hudson from Jersey City to New York, the design and method of construction of which were shown in Compressed Air Magazine for May, involves another and most serious problem, that of ventilation. This, except in a small way, is a new but very imperative requirement. The principal vehicles to use the tunnel would be gasoline driven motor cars, and the noxious gases from these if not systematically and very completely taken care of, would render traffic impossible.

Instructive experience in this direction has been had in the London tunnels. In the Rotherhithe tunnel on one typical day, the average traffic between 8 a. m. and 8 p. m. included 104 motor vehicles and on another day 186. Even with this comparatively small motor traffic it was found that the ventilation was distinctly bad and it was quite evident that, with the increase in motor vehicles, artificial ventilation will shortly have to be provided. On certain days the air in the tunnels is reasonably fresh, while on others, with equal traffic, it is very bad, depending upon the direction of the wind, and upon atmospheric conditions.

The land sections between the open ends and the first shafts are short and generally well ventilated, as fresh air enters the open ends and blows out at the first shaft. The inner sections, failing to get fresh air in any quantity from the entrances, depend upon the ventilating shafts to exhaust the bad air, which is then replaced by partially vitiated air from the outer sections. Ordinarily, the air in these sections, while unpleasant to breathe and trying to the eyes, is not so thick that it interferes in any way with traffic, but on days of great humidity the air in the inner sections is so heavy with smoke and vapor that it is impossible to see an approaching vehicle one hundred feet away. Tunnel employes work continuously in this atmosphere with no apparent ill effects.

The fact that there have been no serious prostrations, notwithstanding the passage of as many as 84 motor vehicles per hour through 1,200 ft. of practically unventilated tunnel, indicates that, with proper artificial ventilation, a much larger number of motor vehicles can pass in safety.

EXPECTED TRAFFIC IN THE BIG TUNNEL.

In the case of the proposed Hudson River tunnel it is estimated that the motor traffic per day will be not less than 4,250 motors in 1920, 6,870 in 1925 and 10,100 in 1930. It is also necessary to consider that on days when navigation on the river is impeded by fog, ice, or other adverse conditions, all of the motor vehicles in the district now served by the five downtown ferries would seek the tunnel and that, therefore, ventilation and other facilities should be provided for not less than 10,000 motors per day, with the possibility of increasing the facilities so as to provide against double that number.

AN EXPERIMENTAL TUNNEL SECTION

One of the first steps taken, therefore, in the development of the project was to conduct a series of experiments to see whether it was feasible to take care of the fumes arising in the tunnel, especially on account of its great length of about 3,724 ft. between the two pierhead lines. These experiments were made under the auspices of the Public Service Corporation of New Jersey on its property at Passaic Wharf, in Newark.

An air-tight building was constructed 125 ft. long, as a model of a section of the proposed tunnel, with roadways, sidewalks, etc., complete, including air ducts with openings into

the top and bottom of the tunnel, and electrically-operated blowers and exhaust fans of proportionate size.

The tunnel section was filled with gasoline motor trucks and automobiles of various sizes, to the number of eight in all, and a series of tests was made under the direction of Dr. Gellert Alleman, of Swarthmore College. Samples of air taken at many points in the tunnel, with all the cars running, throttled down and racing, with and without ventilation, were analyzed. Tests were made with fresh air introduced at the top and exhausted at the bottom and similar tests with the direction of the air reversed. The volume and velocity of the air so introduced was measured, and a chemical analysis made of the air samples taken during these tests.

Figs. 1 and 2, reprinted from Heating and Ventilating Magazine, show the arrangement of the section as tested.

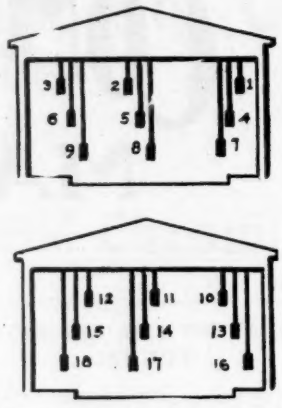


FIG. 1. LOCATION OF PIPETTES

CONCLUSIONS OF TESTS

From the analytical results obtained Dr. Alleman draws the following conclusions:

1. When all doors and ventilators are closed and the engines of eight cars are racing for thirty minutes, the atmosphere becomes intolerable; the high content of unsaturated hydro carbons ("smoke") being responsible for a marked irritation of the eyes and respiratory organs, and the carbon monoxide producing distressing physiological disturbances. Such an atmosphere must be regarded as dangerous to persons who breathe it for a continuous period of fifteen minutes.

2. When all doors and ventilators are closed and the engines of eight cars are "running light" for thirty minutes, there is a marked improvement in the condition of the atmosphere as indicated under Test 2, but the breathing of such an atmosphere for a continuous period of fifteen minutes must also be regarded as dangerous.

3. When all doors are closed and the ventilators are open and exhausting from the top of the tunnel, with the engines of eight cars racing for thirty minutes, there is a further improvement in the condition of the atmosphere over that indicated under Test 1 and Test 2. However, the carbon monoxide content of this atmosphere must be looked upon as probably dangerous either to those persons who are physiologically weak, or to those persons who are particularly susceptible to this gas and who breathe it for a continuous period of thirty minutes.

4. When all doors are closed and the ventilators are open and exhausting from the top of the tunnel, with the engines of eight cars "running light" for forty minutes, the condition of the atmosphere is almost normal and the carbon monoxide content is not dangerous.

This conclusion is further supported by the fact that the eighteen persons who remained in the tunnel during this test, for a continuous period of forty minutes, experienced no unpleasant sensations from breathing this air and no subsequent distress.

5. When all doors are closed and the ventilators are open and exhausting from the bottom of the tunnel, with the engines of eight cars all racing for thirty minutes, the condition of the atmosphere is much worse than in Test 3, where the same conditions prevailed, except that the exhaust was made from the top of the tunnel. Such an atmosphere is not only unpleasant, but must be regarded as dangerous if breathed continuously for a period of thirty minutes.

6. When all doors are closed and the ventilators are open and exhausting from the bottom of the tunnel, with the engines of eight cars all running light for thirty minutes, there is only a slight improvement in the condition of the atmosphere over that indicated in Test 5. Moreover, the condition of this atmosphere is much worse than the air in Test 4, when the same conditions prevailed, except that the exhaust was made from the top of the tunnel. Such an atmosphere is unpleasant and must be

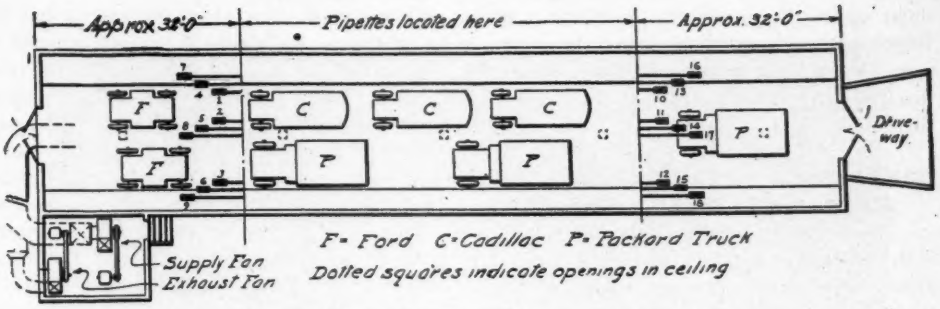


FIG. 2. PLAN OF EXPERIMENTAL TUNNEL SECTION

regarded as dangerous if breathed continuously for a period of 30 min.

7. It appears that the direction of the exhaust air is of considerable importance, the most satisfactory results being obtained when the air enters the tunnel at the bottom and is withdrawn at the top. This was to be expected because of the fact that the exhaust gases leave the motors at a high temperature and are consequently lighter than air, and rapidly diffuse upward. The lateral propulsion of these heated gases into the atmosphere produces a motion which mixes the exhaust gases with the air, thus accounting for the fairly uniform distribution of the products of combustion in the atmosphere of the various parts of the tunnel.

8. Some of the odors which are unpleasant are in no sense dangerous and are produced by the "cracking" of lubricating oil.

These tests prove that the general method of ventilation outlined for the tunnel is entirely feasible, and that the products of gasoline combustion and smoke can be overcome by the introduction of air in the quantities specified and exhausted as described, leaving the air practically normal.

MODIFICATION OF VENTILATING SYSTEM

The system of ventilation shown in the plan (Fig. 3), in which the exhaust air is drawn out from the two roadways through grating in the pavement, is only tentative. There is no question that this system would be effective with sufficient capacity provided in the exhaust fans. Subsequent studies of the question, however, show that the method is uneconomical and it is likely that the system that will finally be adopted will force the air from the shafts at the bulkhead lines into the tunnel to the center, at which point effective means will be provided for exhausting the air through large ducts back to the shafts.

It is probable that toward the middle of the tunnel there would be additional intake and exhaust facilities.

Forty-five air changes per hour in the tunnel is the minimum quantity at present under consideration, which, it is estimated, would give an entirely satisfactory diffusion of CO and CO_2. In fact, such a quantity of air, the designers state, would give substantially open-air conditions, with an assumed traffic of three lines of motor trucks every 60 ft. moving 10 miles per hour, and using the worst proportion of gasoline and air for combustion.

It is recommended that ventilation shafts be constructed at the bulkheads on each side of the river, where they would offer the least obstruction. The semi-circular arch approach tunnels would be ventilated through specially designed electric light posts, the bottom part of which would consist of cylinders of sufficient diameter to afford the necessary capacity for the intake and exhaust blowers, which would be situated in the arches above the roadways at proper intervals.

It is contemplated that the intake blowers would discharge the fresh air at the top of the roadways2 of the tunnel and into the semi-circular spaces where the blowers are situated. The exhaust blowers would be connected to a separate system of

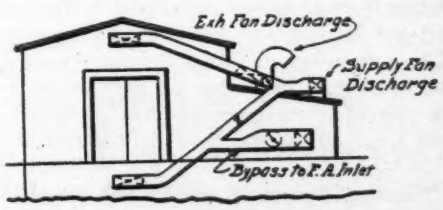


FIG. 3. ARRANGEMENT OF DUCTS

ducts under the pavements, each for a given length of roadway, discharging the foul air through the light posts sufficiently above the level of the streets to obviate any nuisance therefrom.

COMPRESSOR EXPERIENCES WITH SUBMARINE DIESEL ENGINES

By Lieut. F. C. Sherman, U. S. N.*

Diesel engine air-compressor troubles comprise valve trouble, cooler leaks and explosions. They are due to the high temperatures created when the air is compressed in two or more stages from atmospheric pressure to approximately 1000 lb. per sq. in. In the type of engine mentioned at the beginning of this paper, the compressor was designed to take its suction from the scavenger-air housing, and it was then compressed in two stages in tandem to 800 lb. to 1000 lb. per sq. in. This air was cooled from each stage in a cooler consisting of nests of small, straight tubes around which circulated cooling water. The air from the second-stage cooler passes to the spray-air bottle which acts as a reservoir on the way to the spray-air line of the engine. It will be seen that when the two-stage air compressor takes its suction from the scavenger housing containing air at 7 lb. pressure (above atmosphere) it virtually makes a three-stage compressor. On our engine, however, there was always so much oil in the scavenger housing that it was considered dangerous to compress air containing so much oil and subject it to the temperatures reached, and in practice it gave considerable trouble. So the suction to the scavenger housing was disconnected and a suction direct to the atmosphere substituted which gave a straight two-stage compression from athospheric pressure to 1000 lb. per sq. in. This worked much more satisfactorily as regards presence of oily vapor in the compressed air and occurrence of cooler explosions.

A common practice in Diesel-engine design seems to be to have a restriction in the spray-air line between the reservoir and the engine. The only object of this, that I have been able to discover, is to enable a higher pressure to be carried in the reservoir than is needed on the spray-air system, so as to build up a reserve for starting after the engine has been shut down. If this is its purpose, it never was successful for us, and only resulted in reducing the amount of spray air we were able to get through to the fuel valves. Furthermore, it would frequently clog up and catch dirt and oil to further reduce the opening, so that in general it was more of a nuisance than anything else. Acting on this belief, the restriction on the spray air was removed entirely and much better results in every way were obtained. Whereas before, poor fuel combustion had been obtained when carrying 800 lb. to 900 lb. pressure on the spray air, after removing the restriction perfect combustion was obtained with as low as 550 lb. to 600 lb. pressure on the spray air.

USING NO OIL FOR LUBRICATION

Another point in regard to air-compressor trouble is cylinder lubrication. The principal danger is too much lubrication, allowing oil to be carried into the compressed air and causing high temperatures or explosions from burning or combustion of the oil vapor. The best practice is to eliminate direct cylinder lubrication entirely and depend on the moisture and oily vapor in the engine-room atmosphere to furnish sufficient lubrication. In practice this worked very well for us, and we had no trouble from lubrication while using no oil whatsoever directly on the air compressors.

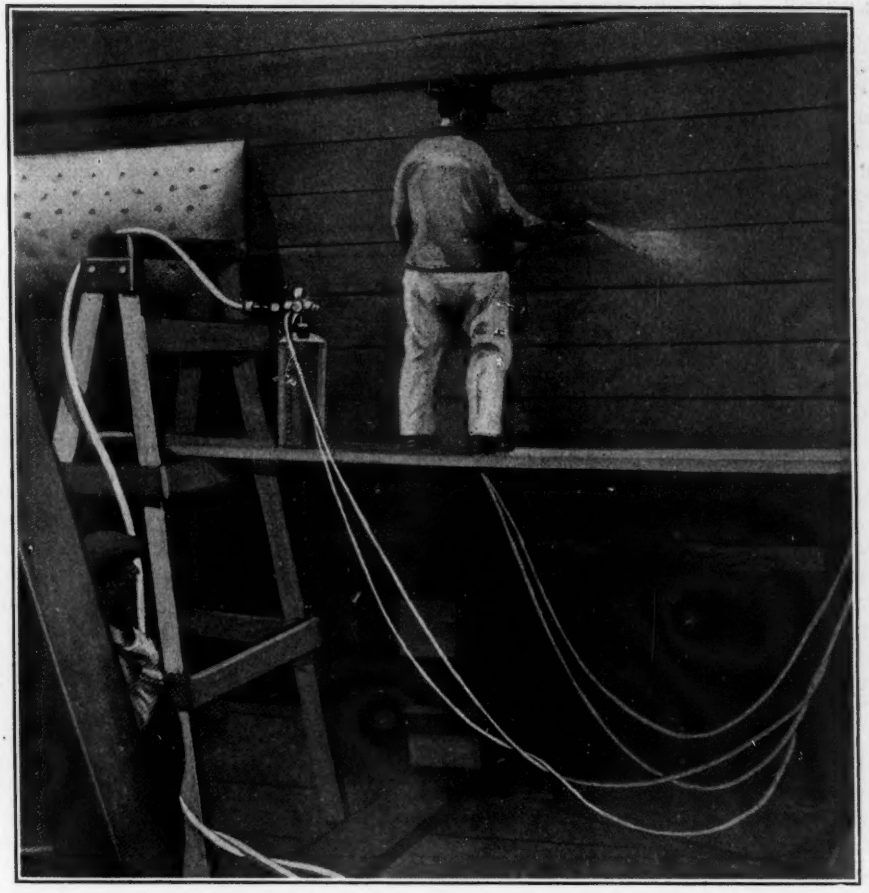
VALVE TROUBLES

The principal valve trouble which we experienced was due to the valve springs losing their temper after a few hours' running, due to the high temperatures of the uncooled air to which they were subjected. The second-stage suction valve was the principal source of trouble, and when its spring gave out it would leak, allowing second-stage pressure to back up in the first-stage receiver and increase the work on the first stage and in general raise hob. Another source of valve trouble was the gradual collection of carbon deposits on the valve seats due to the presence of oil in the air and causing the valves to leak.

WATER INSTEAD OF OIL

Cutting off the oil used for cylinder lubrication helped both troubles. But the greatest assistance to correct these faults was a water cup installed on the first-stage air suction and set to feed a small quantity of fresh water into the compressor with the air. This water cup was simply a large oil cup arranged for drop

*Journal American Society of Naval Engineers.



COMPRESSED AIR PAINTING A WOODEN SHIP

feed, filled with fresh water instead of oil. A fairly rapid feed was set on it, about two to four drops per second, and this water was dropped through the top of the air-suction pipe and drawn into the compressor with the air. The action of this fresh water was found to be as follows: It helped to lubricate the valves and cylinder walls and prevented the deposit of carbon. The high temperature almost immediately turned it into steam, absorbing some of the heat without rise of temperature in the form of latent heat, and thus keeping down the temperatures developed due to compression. In addition the steam kept the carbon from collecting and gumming up the valves, and the reduced temperatures resulting prevented the springs from losing their temper. This fresh-water cup was a fine thing, and I strongly advise other Diesel-engine operators to try it on their air compressors.

THE METHANEPHONE

This is a little instrument recently perfected by a young Welsh professor in London for the protection of mine-workers. It consists of a small wooden box about 9 inches high containing an electric battery. At the top of the box is a fuse head cap upon which a tiny light always glows from the battery beneath. As soon as a certain low percentage of methane gas enters the workings its presence causes a tiny explosion in the fuse head, the explosion in turn melting a fine wire filament, which starts a bell to ringing continuously. The men in the vicinity are thus notified that gas has made its appearance and can take the necessary precautions. Officials of the Miners' Federation of Great Britain have witnessed effective tests of the methanephone.

TESTING AN AIR COMPRESSOR

By Walter S. Weeks*

When a compressor is sold it is guaranteed to have a certain volumetric efficiency by orifice test.

This efficiency is determined as follows: The air delivered per minute by the compressor is measured. The volume of this air is calculated under the conditions that prevailed at the intake of the compressor. This volume is divided by the volume swept per minute by the piston of the low-pressure cylinder. The result is the efficiency sought. The piston rod should be neglected.

The term volumetric efficiency is also used in comparing the performance of a compressor at different altitudes and with different intake temperatures. This use of the term is in my opinion unnecessary and confusing. The whole subject may be clarified by using the term 'volumetric efficiency' only for that given by the orifice test and stating the air-consumption of tools in subic feet of compressed air at a given gage-pressure.

An example, if I may digress for a moment, would be something like this: An air-drill requires 10 cu. ft. of compressed air at 90-lb. gage. The altitude is 10,000 ft. The temperature of the mine is 100°F. The temperature of the compressor-room is 60°F. What must be the displacement of the low-pressure cylinder to run 10 drills? The volumetric efficiency of the compressor by orifice test is 80%.

Compressed air needed $10\times10=100$ cu. ft.

Ratio of compression at 10,000 ft. $=\frac{90+10}{10}=10$

Free air needed $=10\times100=1000$ cu. ft.

1000 cu. ft. is needed in the mine at 100°F. It is 60° in the compressor-room, so the free air at the temperature at the compressor-room is $\frac{520}{560}\times 1000=929$. The compressor will deliver, at this altitude, according to the maker, only 80% of the piston-displacement, hence the displacement needed is $\frac{929}{0.8}=1161$ cu. ft.

The vital questions about an air-compressor are: How much does the compressed air cost, and is the compressor doing all that it should?

To answer these questions we must measure our power input, we must measure the air delivered, we must take indicator-cards on the air end, and determine the displacement.

The measurement of power on the driving side is familiar to all, but a rapid way of measuring the air may not be quite so familiar. The air is best measured by what is known as the low-pressure orifice method (Fig. 1). All the compressed air that the compressor will make is discharged from the receiver through a valve *a* into a tank *b* in which is placed a nozzle or orifice *c*. The valve is closed until the compressor will just hold the receiver pressure desired. The pressure just back of the nozzle is taken with a water manometer *d*, and its temperature is taken with a thermometer *e*. From these data, with the size of the nozzle, the air flowing per minute may be computed.

The flow through an orific is assumed to be adiabatic, but an adiabatic formula is cumbersome. If we assume that the density of the air is a mean between the density inside and outside the tank, a simple formula can be developed from the basic principle that $V=\sqrt{2gH}$. This simple formula agrees with the adiabatic formula up to 18 in. of water. A discussion of the development of the simple formula may be found in 'Engineering Thermodynamics,' by C. E. Lucke.

The formula there given is pounds of air per second through a circle of

$$d \text{ in. diam.} = 0.01366\, d^2\sqrt{\frac{h_w P}{T}}$$

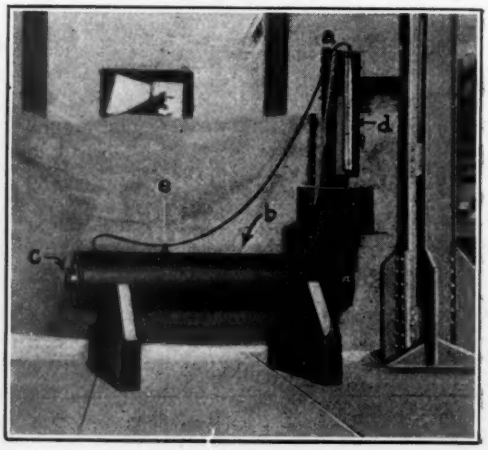


FIG. I

*Associate Professor of Mining, University of California.

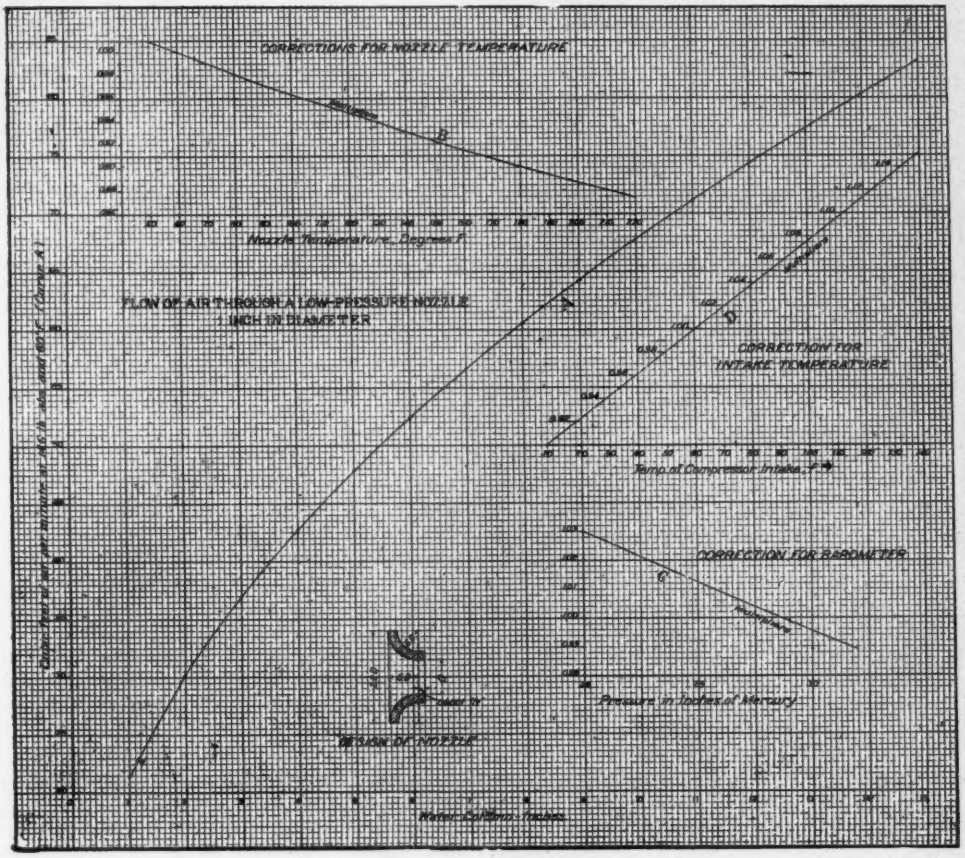


FIG. 2

d=diam. of nozzle in inches.

h_w=difference in pressure on the two sides of the nozzle in inches of water (never over 18 in.).

P=mean pressure on the two sides of nozzle in lb. per sq. ft.

T=absolute temperature back of the nozzle in degrees F.

What we are after is the cubic feet of free air delivered per minute under intake conditions. Curves may be plotted to make our computations easy.

To find the weight per minute multiply by 60.

$$W = 0.81960\ d^2 \sqrt{\frac{h_w P}{T}}$$

First assume the nozzle to be 1 in. diam., the nozzle temperature 60°F., the barometric pressure 14.6 lb. per sq. in., and determine the weight that will flow out per minute with water-gages from 1 to 15 inches.

After these weights are determined, calculate the volumes under a standard set of conditions by the formula

$$V = \frac{w R T}{P}$$

V=volume in cu. ft.

w=weight in lb.

R=53.34.

T=absolute temperature=520°F.

P_s=absolute pressure in lb. per sq. ft.=14.6 ×144=2102.4.

We now have the data for curve A (Fig. 2). The values plotted include a coefficient of flow for the nozzle of 0.98, which from various investigations appears to be reasonable.

Now suppose the nozzle temperature instead

of being 520° abs. is some other temperature T_1 abs. We can determine the flow by multiplying the values on curve *A* by $\sqrt{\frac{520}{T_1}}$. The measured at 60°F. This correction is plotted in curve B. ....

Now suppose the barometric pressure is not 14.6 but some other pressure P_1 lb. per sq. in. In formula No. 1 P is the average pressure in lb. per sq. ft. Let Pm_1 be the average pressure in the same units when P_1 is the barometric pressure. The flow of air when the barometer is P_1 may be obtained by multiplying values air after making this correction will still be from curve *A* by $\sqrt{\frac{Pm_1}{P}}$

Without appreciable error we may use the ratio of barometric pressures instead of the average pressures. So we way multiply by $\sqrt{\frac{P_1}{14.6}}$ instead of $\sqrt{\frac{Pm_1}{P}}$

After making this correction the air would still be measured at 14.6 lb. per square inch. We want the volume at pressure P_1 so we must multiply by $\frac{14.6}{P_1}$; thus the total correction will be $\frac{14.6}{P_1}\times\sqrt{\frac{P_1}{14.6}}=\sqrt{\frac{14.6}{P_1}}$

This correction forms the basis for curve *C*. I have used inches of mercury for the barometer pressure because most aneroid barometers read this way.

After making the corrections for nozzle temperature and barometer we have the air at 60°F. and at the barometric pressure existing. There remains still to compute the volume at the intake temperature. This correction is merely the ratio of the absolute temperatures and is plotted in curve *D*.

The final result must be multiplied by the square of the diameter of the nozzle in inches.

Example of the use of the chart:

Nozzle 2 in. diam.

Water column 8 in.

Nozzle temperature 80°F.

Barometer 30 in.

Intake temperature 90°F.

Curve *A* 60.6 cu. ft. at 14.6 lb. per sq. in. and 60°F.

Curve *B*, 0.981. z

Curve *C*, 0.995

Curve *D*, 1.058.

Square of diam., 4.

Total correction, $0.981\times0.995\times1.058\times4=4.131$.

$4.131\times60.6=250.34$.

The nozzle then is discharging each minute 250.34 cu. ft. air at 90°F. and 30 in. of mercury. This figure divided by the displacement gives the volumetric efficiency.

Let us suppose that we are testing a two-stage compressor driven by a belt-connected induction-motor.

An indicating wattmeter gives the power-input.

The air-cylinders should be fitted with indicators.

Tests should be run at various gage-pressures. Let us suppose we are running a test at 90-lb. gage.

All gages should be calibrated. Discharge all the air that the compressor makes through the nozzle and adjust the valve to the tank till a pressure of 90 lb. is maintained in the receiver. Let the compressor run under these conditions for 15 minutes. Read wattmeter, water column, nozzle temperature, intake temperature, barometer, r.p.m., and take indicator-cards.

The horse-power calculated from the indicator-cards divided by the horse-power input gives the over-all mechanical efficiency.

From the cost of power, the kilowatt input, and the air delivered, may be calculated the cost of compressed air per unit.

The air delivered divided by the displacement of the low-pressure cylinder gives the volumetric efficieny.

With the aid of the low-pressure indicator-card we can determine the slippage.

The actual volume of air taken in each stroke at atmospheric pressure is represented by the length of the atmospheric line included in the indicator diagram. Glancing at Fig. 3: if *A B* represents a displacement volume *K* then the volume of air taken in each stroke at atmospheric pressure is $\frac{C\,D}{A\,B}\times K=L$.

Less air is taken into the crank end of the cylinder than into the head end because the piston-rod takes up room; therefore the displacement of each end must be figured separately

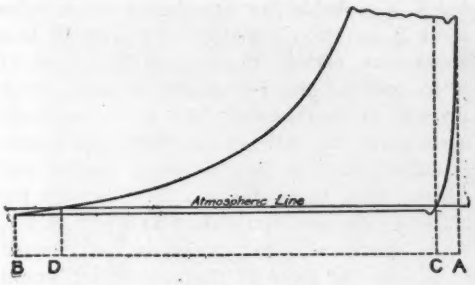


FIG. 3

Let L_1=volume at head end at atmospheric pressure.

Let L_2=volume at crank end at atmospheric pressure.

Let S=r.p.m.

Then the number of cubic feet of air that actually enters the compressor each minute at atmospheric pressure is $(L_1+L_2)S=M$.

The air delivered as measured by the nozzle divided by M gives what is called the slippage efficiency. It is assumed that the air is not heated on its way into the compressor. The air must be warmed somewhat, just how much in a fast-running compressor, I don't know. A little study will show that the warming of the air will make this efficiency appear lower than it really is. Even if the method is not rigidly accurate, it will detect leakage by the piston and through the valve.

S. B. Redfield, testing engineer for the Ingersoll-Rand Co.. to whom I am indebted for much information, has used a similar chart for many years in testing the many compressors turned out by the plant, and has found the method most satisfactory. On the chart is a sketch of the nozzle adopted by Mr. Redfield. Fig. 4 is a photograph of a nozzle. A casting should be made of brass and the nozzle threaded to screw into the tank. The nozzle should be polished. For a test a nozzle should be selected to keep the water gage less than 15 inches.

The area of the tank should be twenty times the area of the nozzle. An even flow through the tank is desired. The globe valve admitting air to the tank may be made delicate by fastening a long lever to the handle. When a compressor is purchased, specification should be made that it be tapped for indicators. These holes are handy in testing the tightness of valves and pistons.

It would be an excellent idea if the makers of air-compressors would agree on a standard method of testing. As the case stands at present a comparison of guarantees is impossible because the compressors are tested by different methods. The important guarantee of a compressor is the horse-power input per 100 cu. ft. air delivered. The way that the air is measured should be carefully scrutinized.

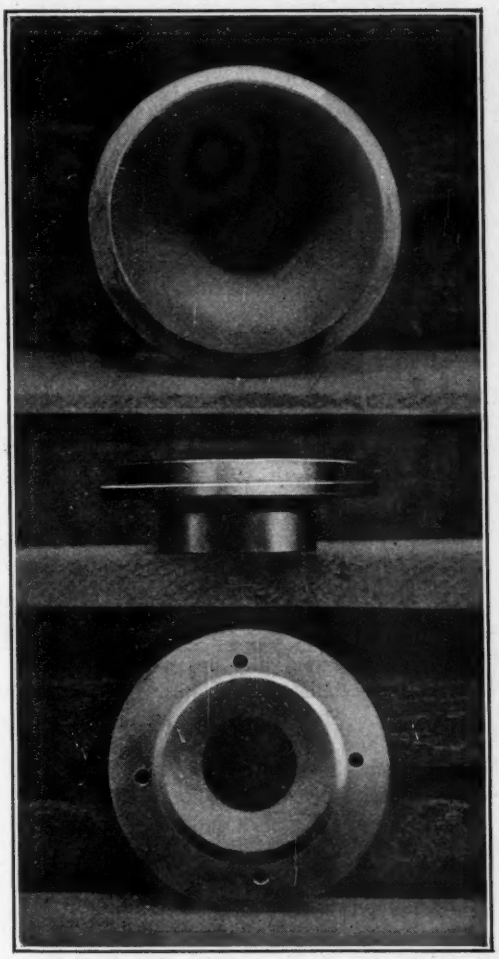


FIG. 4

In order that curve A may be plotted to a more open scale, I append the values from which it is plotted.

Water-col. in inches	Cu. ft. of air	Water-col. in inches	Cu. ft. of air
1	21.32	9	64.28
2	30.17	10	67.79
3	36.97	11	71.15

4	42.72	12	74.36
5	47.79	13	77.44
6	52.39	14	80.41
7	56.62	15	83.28
8	60.57		

—*Mining & Scientific Press.*

THE INVERTED DEPTHS OF THE ATMOSPHERE

The sensational German feat of dropping shells on Paris has awakened a great deal of interest in the nature of the air through which the shell plows its way on its 120-mile course; for while the actual range of the gun is in the neighborhood of 75 miles, assuming that the gun is elevated to an angle of 43½ degrees, the shell must rise to an altitude of about 24 miles above the earth. We do not know much about the condition of the atmosphere above an altitude of 7 miles except by theoretical reasoning. The maximum elevation ever reached by man is probably that attained by Glaisher and Coxwell on September 5, 1862. Mr. Glaisher made his last observation when his balloon had carried him up 29,000 feet. He was then ascending at the rate of 1,000 feet per minute. Shortly after that he lost consciousness and Mr. Coxwell, his assistant, also began to lose the use of his muscles. However, he succeeded in stopping further ascent by pulling the valve cord with his teeth, as his arms were powerless. Thirteen minutes later Mr. Glaisher regained consciousness and then found that his balloon was descending at the rate of 2,000 feet per minute; from which he estimated that, in the interval, they must have reached the extreme altitude of over 36,000 feet. In 1901 the German balloon Preussen reached an altitude of 35,100 feet. These are the highest altitudes ever reached by man, and they are not one-third of the altitude that must be reached by the shells fired from the Forest of St. Gobain.

Judging from the curve of pressures recorded in the lower strata of the atmosphere it is assumed that there is a very high vacuum at that height. Of course, this does not mark the limit of the earth's atmosphere. Meteorites come shooting down to the earth with velocities up to 20 miles per second leaving a trail of fire caused by the friction with the air or with gases surrounding the earth. These trails have been observed as high as 200 miles, but it is probable that at a height of 24 miles there is so little air that the sky loses its blue appearance, because there is hardly enough of it to produce the refraction of light which gives it its luminosity. And so, if we could accompany this shell on its course, we should probably find the sky growing darker and darker, until it became nearly black. In the black sky the sun would show as a ball of fire, while the stars which were not obliterated from view by glare of the sun's light, would also be visible. Below us we should have the reflection of sunlight from the earth and from the denser strata of the atmosphere.—*Scientific American.*

THE LADY CONTRACTOR

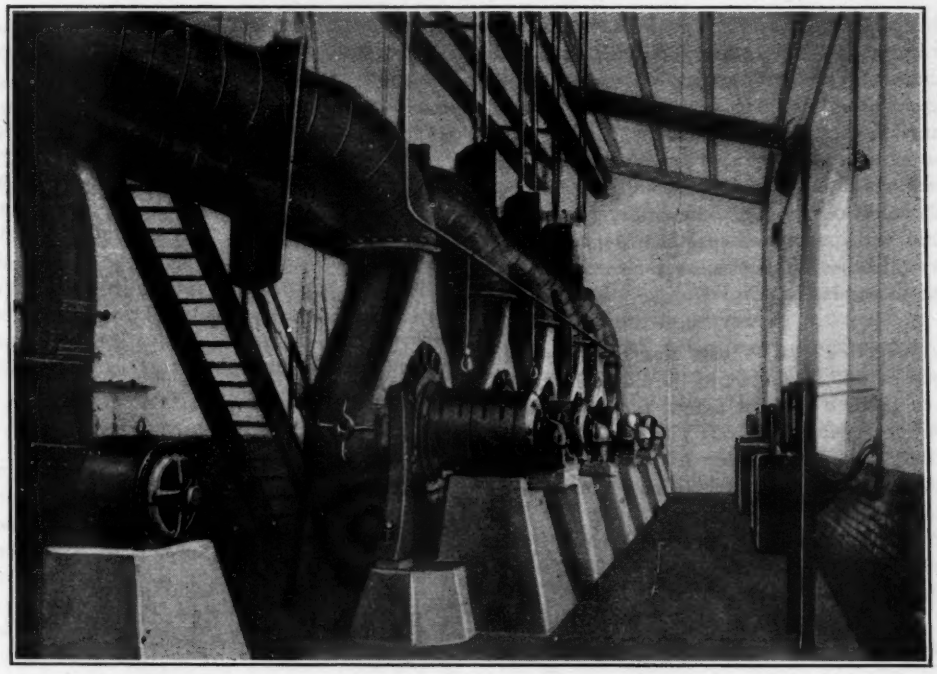
You see, F. H. Davis, a young contractor living in Fresno County, California, secured a $59,000 road contract. A few days later after starting work he received a letter summoning him to a training camp. Davis, anxious and determined to serve his country, was distressed by the prospect of being forced to abandon his road contract. The perplexity of his problem was suddenly lifted by the inspiration of his wife, who ventured the suggestion that she could learn to operate the big White five-ton truck and Austin road machinery and carry the contract to a successful finish.

Hazel climbed into hubby's overalls and onto the truck. Davis showed her how to operate the different levers and, after a few days' coaching, she proved her ability to handle the machinery and boss the job.

Hazel's crew was, at first, inclined to loaf on the job and take advantage of the "woman boss." But she does not countenance "slackers."

While her husband is being turned into a first-class fighting man Hazel is carrying on the work and has received the first payment on the contract—a check for $10,000.

Davis isn't the contractor's real name—but the story is based on real facts taken from the experience of a contractor who really was drafted and whose wife came to the front just as "Hazel" did in this movie, which is being produced by the National League for Women's Service, to show woman's usefulness in the war. So while the lady contractor is not yet an everyday sight, except in the film world, she's on the way—*The Contractor.*



THE LARGEST BLOWER INSTALLATION FOR PULVERIZED FUEL

SAVING OUR NATIONAL RESOURCES BY USING PULVERIZED FUEL

Attention is specifically called in this article to the extent of the use of pulverized fuel in the industries, and its helpful warlike possibilities. The half tone above, here reproduced from General Electric Review, May, 1918, shows a line of seven electric driven centrifugal air compressors or blowers installed at the Washoe Smelter of the Anaconda Copper Mining Company, Anaconda, Montana. These machines are of 10,200 cu. ft. capacity each, and furnish the air for blowing pulverized coal into reverberating copper smelting furnaces. They collectively deliver over 70,000 cu. ft. of air per min. at a gage pressure of 1 lb. per sq. in., drawing in considerable additional air by induction. This plant is at an altitude of 5,000 ft. above sea level and is the largest pulverized coal installation in existence, although another installation of six similar units is underway at the new smelting plant of the United Verde Copper Company, Clarkdale, Arizona.

The above illustration accompanies a valuable article by Mr. F. P. Coffin, of the Research Laboratory of the General Electric Company, summarizing the advantages of pulverized fuel and the reach of its adaptability, what follows being a brief abstract of the article spoken of.

GENERAL ADVANTAGES.

1. Flexibility of control of both fuel and air, and ability to extinguish instantly.

2. Complete combustion, even at high rates of burning, and elmination of smoke.

3. Burning fuel in suspension eliminates the usual troubles resulting from the formation of clinkers.

4. Low-grade fuels may be burned efficiently regardless of the proportions of ash, sulphur or other impurities.

5. Very little excess air is required, which reduces the slack loss and the power required, and also the areas of flues and stacks.

6. Maximum fuel economy is made possible in many applications.

7. The expense of supplying coal to scattered industrial furnaces is reduced to a minimum. Pulverized fuel has semifluid properties; it flows easily and can be transferred through pipes:

a. By screw conveyors.

b. In a mass by means of compressed air.

c. In suspension in a current of air.

IN INDUSTRIAL FURNACES.

Pulverized coal was first utilized in the United States about twenty-six years ago, for economically burning cement rock in the rotary kilns of the Portland cement industry. It has now largely replaced more expensive fuels such as oil, in parts of the country where coal is readily obtainable. The rotary cement kiln fired with pulverized coal has been applied in several other industries, as for calcining various minerals.

DRYING.

Pulverized coal is used for drying cement rock before feeding it to the kilns, and it has been used to a small extent for firing rotary coal dryers in pulverizing plants. One plant is installing equipment for drying bauxite in a rotary kiln. In the fertilizing industry it is used for drying tankage (garbage and sewage), for drying and slightly roasting phosphate rock, and for drying feldspar shale in rotary kilns for use as fertilizer filler.

METALLURGICAL FURNACES.

The most important application in which pulverized coal has made notable progress in the last few years is in the metallurgical field. Marked economies have been attained by the application of this fuel to furnaces used in the manufacture of iron, steel, copper, zinc, galvanized iron, and tin plate.

The application of pulverized coal in the metallurgical industries is still in its infancy, but the list of plants using it shows that it has made good progress.

The shortage of natural gas in some localities has been an incentive for the greater use of pulverized coal, and the high cost of fuel oil has been an additional incentive.

On the average, the substitution of pulverized coal as a fuel for metallurgical furnaces has resulted in a saving of about 33 per cent of the fuel required when burning coal in other ways.

One feature of interest in this connection is a comparison of the percentage of excess air required when burning various fuels in metallurgical work.

Pulverized Coal	5 to 25 per cent
Hand-fired coal.....	100 to 125 per cent
Stoker-fired coal	50 to 100 per cent
Producer gas	50 to 75 per cent
Natural gas	40 to 50 per cent
Fuel oil	50 per cent and upward

The field of steam generation may be subdivided into three classes: stationary boilers, locomotives and steamships.

STATIONARY BOILERS

The high efficiency attainable with modern mechanical stokers has rendered the introduction of pulverized fuel for boiler firing less attractive, at first sight, than in the case of industrial furnaces. The development of the underfeed stoker has forestalled pulverized fuel in this field so that the latter has a more difficult field to travel. Pulverized coal may be regarded as the ideal fuel, but the additional machinery required is a handicap.

LOCOMOTIVES.

On locomotives hand firing still persists owing to the difficulty of making satisfactory stokers to operate within the limited space available. The steaming capacity of large locomotives is often seriously limited by the inability of the fireman to shovel coal fast enough to maintain full steam pressure, and by the continual opening of the fire door which disturbs uniform draught. In the western states, where only poor grades of coal are available, this difficulty with hand firing has often led to the substitution of oil-burning engines on mountain grades. In this service it is difficult to burn oil efficiently when forcing the boilers. Pulverized coal has the same advantages as fuel oil in locomotive service in regard to stoking and, in addition, efficient combustion can be maintained at high rates of burning.

Pulverized fuel is already being used on a commercial scale on locomotives in two foreign countries. The Central Railway of Brazil has twelve locomotives operating with Brazilian coal and American equipment. This coal has such a high sulphur content that it has not been successfully burned in any other way. Brazil has always imported its coal heretofore, although enormous deposits of native coal are available. Additional locomotives are now being equipped.

One line of the Swedish government railways, 60 miles in length, is being operated with locomotives burning peat powder. This is burned in suspension in the combustion air similarly to pulverized coal. The development work was carried on by the Swedish government with a view to replacing imported coal.

STEAMSHIPS.

Fuel oil has made considerable headway in displacing coal, both in the merchant marine and in the navies of several countries, in spite of its high cost in some parts of the world. Its advantages over hand-fired coal are:

1*m* Saving of stokehold labor.
2 Fuel handling is reduced to the simple operation of pumping oil through pipes. This applies both to oiling the ship and to feeding the burners from tanks located in any part of the vessel.
3 Cleanliness.
4 Low fireroom temperature.
5 Higher calorific value.
6 Higher efficiency in boiler firing.
7 Ability to operate boilers at a higher rating.
8*m* Ability to force boilers instantly when an attack demands a sudden increase of speed.
9*m* Smokeless combustion.
10*m* Ability to work up a smoke screen instantly by overfeeding fuel.

The four advantages marked (*m*) are of especial military value. By establishing pulverizing plants at ports, coaling stations, or on board naval colliers, pulverized coal could be used on ships with practically all the listed advantages over hand-fired coal, except (5). More tons of coal must be carried than is the case with oil owing to the high calorific value of oil. However, pulverized coal is burned with better efficiency than hand-fired coal, and this fact will partly offset this disadvantage. Oil is burned on shipboard with at least 12 per cent better efficiency than hand-fired coal, and the same should be true with pulverized coal.

Pulverized coal when stored in strong tanks along the sides of a ship presents considerable possibilities in the way of torpedo protection.* The U. S. Shipping Board has recently authorized the building of a large steamship embodying this idea and using pulverized coal as fuel.

NECESSITY FOR CONSERVATION OF FUEL OIL.

The building of so many oil-burning ships, together with the loss of many oil tankers through the operation of German submarines, raises a serious problem in regard to the supply of fuel oil in adequate quantities.

There is a large source of oil available in Mexico but we must build new tank steamers to transport it. The greater part of Mexico's output has come from two wells. This naturally renders the supply uncertain, for oil wells are subject to accidents or fires; besides which this source of supply is not under our control and is in danger of possible interference.

Oil is such a valuable fuel in our industries that it can only be spared if equally practical and efficient fuels are available as substitutes. It is doubtful if fuel oil can be entirely replaced, except by expensive gaseous fuels. Pulverized coal is the most economical substitute for many purposes and is much cheaper than fuel oil at the present prices.

The further industrial application of pulverized coal should release fuel oil for the use of the great fleet now building for the American merchant marine, and for the navy.

This appears to be the most immediately available method of alleviating the situation, but it will not be adequate to release all the oil that will be required.

PULVERIZED COAL FOR OCEAN TRANSPORTS

It is very evident, therefore, that the most effective method of dealing with this phase of the fuel situation is to immediately attack the problem of utilizing pulverized coal on board ship. Like all new developments, this is a problem in which it will take time to work out details in connection with the initial installations, before it can be applied on a large scale.

Pulverizing stations will have to be established at several of our leading ports. As the greater part of our exports to Europe are shipped from Boston, New York, Philadelphia, Baltimore, and Newport News, it will be sufficient to establish pulverizing stations at these five ports where ships may be coaled for the round trip. Commerce from other ports can be carried in ships burning oil or ordinary coal.

The slight disadvantage of limiting a ship to certain ports may be overcome by installing equipment for burning oil as an emergency fuel to enable the ship to complete a voyage from some other port to her home port. Oil may be carried in the double bottom where it will be independent of the coal storage and handling equipment. The same compartments can be used also for shipping oil to Europe as cargo.

ELECTRIC POWER AND PULVERIZED FUEL.

The article from which we are abstracting

*Hudson Maxim, *Scientific American*, Mar. 30, 1918.

speaks of the availability of electric power and of its ready adaptability to all the operations involved in connection with the industrial burning of pulverized fuel, but this is all so obvious that it is not necessary to reproduce it here.

THE APPEAL TO THE STEAM TURBINE ENGINEER.

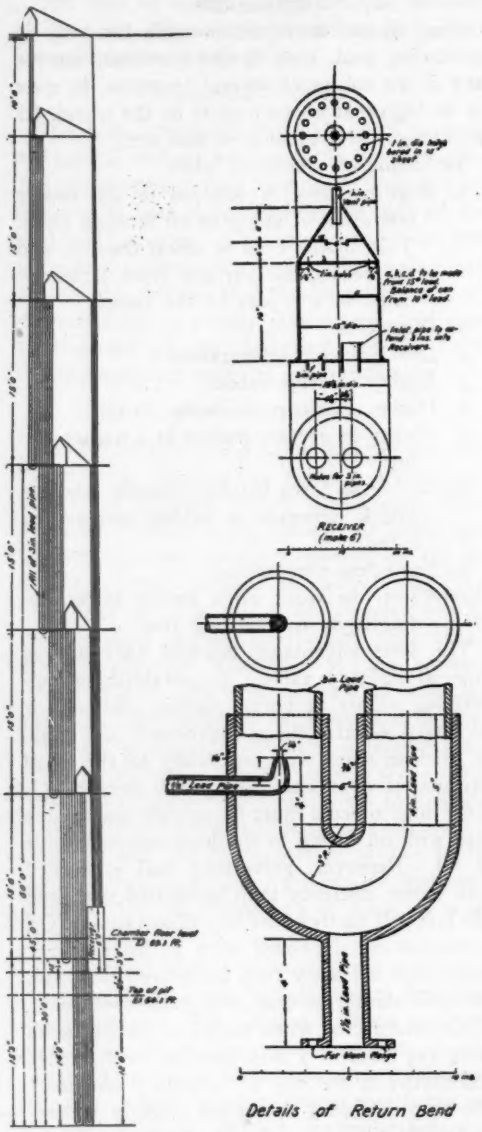
From the point of view of the engineers having to do with the design and development of steam turbines and electrical machinery, it is rather discouraging to see old and wasteful methods of burning fuel persist in the boiler room. They have been gradually bringing the equipment of the generating room up to the highest attainable efficiency by refinements in design and construction. It does not require much in the way of careless firing to nullify their efforts when the overall efficiency of the central station is *the* important consideration in generating electricity from coal.

The underfeed mechanical stoker has much improved the efficiency of the boiler furnace, but it still has its limitations, especially when burning low-grade fuel. With the development of efficient methods of handling and burning pulverized fuel, the power station engineer has another method at his disposal for solving his problems. It may not be universally applicable, in the present state of the art, but it is a great advantage to have two good methods of burning coal under boilers to choose from, each of which has its advantages for certain applications.

The efficient utilization of our low-grade fuels is a matter of ever increasing importance. The re-equipment of old boiler plants for burning pulverized coal may often be more easily accomplished than the installation of efficient stokers, even when good coal is burned.

On shipboard, the steam turbine with mechanical or electrical gearing has much improved the steam economy, and the old-time practice of hand firing should be abolished from the stokehold without further recourse to fuel oil, which is an expensive fuel of limited availability.

It is authoritatively stated that the number of airplanes destroyed by the French aviators and the members of the Lafayette escadrille for a period of ten months was 120 over the French lines and 397 over the German lines, all total wrecks.

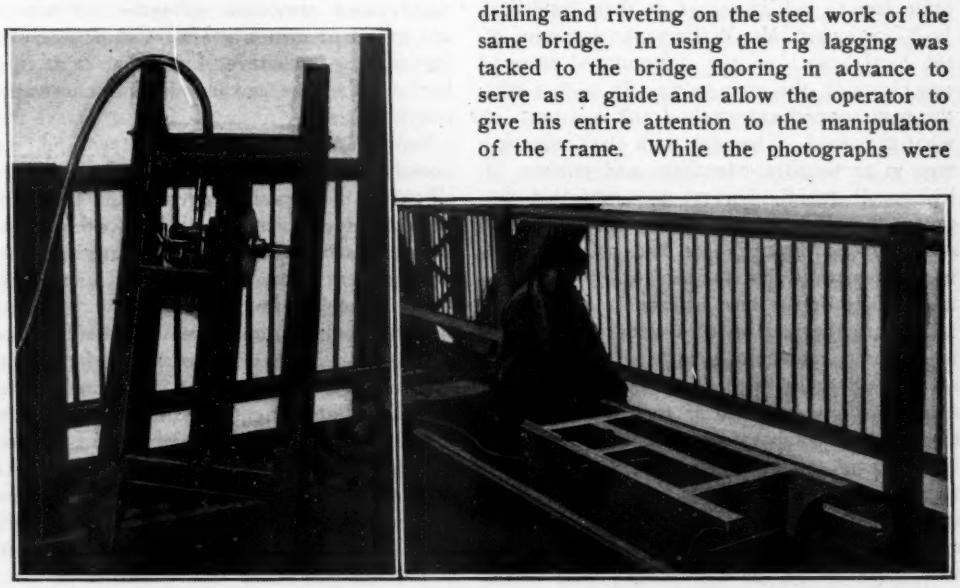


Details of Return Bend

AIR LIFT IN A SULPHURIC ACID PLANT

An interesting, finely illustrated description of the Calumet & Arizona sulphuric acid plant, Douglas, Arizona, is contained in the March 30 issue of Mining and Scientific Press. Of special interest to our readers is an ingenious application of the air lift there employed for elevating the acid. The operation is shown in detail in the accompanying sketch, the total lift being 90 feet. The acid is lifted in stages

through lead pipes, the distance between successive receivers being 15 feet. The compressed air is introduced by a jet, as shown in the detailed drawing, just above the bend of the pipe. The acid flows from the receiver in solid column down the right hand pipe and the levitation accomplished by the air jet carries the acid in the left hand pipe to another receiver 15 feet higher, and so on to the top. The adjustment of the air pressure is controlled by a Davis regulating valve. This device has a pumping capacity of 300 to 500 tons of acid per day.



PORTABLE AIR DRIVEN CIRCULAR SAW

IMPROVISED PORTABLE CIRCULAR SAW

The half-tone above, reproduced from Engineering News-Record, the story accompanying it being told by Charles J. Bennett, State Highway Commissioner, Hartford, Conn., shows how continually new employments of compressed air develop wherever the compressed air habit of thought is cultivated.

Faced with the alternative of removing the guard rail and taking up the entire planking of a bridge 1800 ft. long, the Connecticut Highway Commission devised the special saw rig shown in the illustration, which cut through the first layer of flooring, making it possible to tear up the planking whose replacement was desired without disturbing the part that could still be used.

The saving in labor was considerable and, combined with the greater speed, makes the appliance more than a curiosity.

The circular saw, driven by an air drill, was mounted in an oak cradle of simple construction which was chamfered at one end so that the depth of cut could be regulated by rocking the frame—a simple matter, since the weight of the operator was sufficient. The air drill received its power from a portable gasoline compressor which was being used for some drilling and riveting on the steel work of the same bridge. In using the rig lagging was tacked to the bridge flooring in advance to serve as a guide and allow the operator to give his entire attention to the manipulation of the frame. While the photographs were not taken on the bridge where the rig was used they illustrate the operation perfectly. A. R. Doe, superintendent of bridges, was responsible for the amplification of the suggestion for such a machine.

AIR HAMMERS AND STONE WORKERS

A report by the United States Public Health Service, March 22, 1918, gives in detail the results of a thorough examination of the effects of the use pneumatic tools upon the workers in the Indiana limestone field. The investigations were conducted by J. P. Lake, Passed Assistant Surgeon, and Dr. David L. Edsall, Consultant in Industrial Hygiene, both of the public Health Service.

Dr. Edsall says:

"We requested Mr. Griggs, president of the Journeymen Stonecutters' Association of North America, the local officers of the stonecutters' association, and many of the men in both Bedford and Bloomington to bring to us those who complained most, or we got their addresses and went to their homes. None of the men that we examined were sent to us through the employers, and none were examined in the presence of the employers or their representatives. In Bedford we reached them chiefly in their homes. This had the advantage of making them and their households feel quite free to talk in regard to their condition. In Bloomington, Mr. Walters, the secretary of the local branch of the stonecutters' association, brought the men to us. In both places the men seemed extremely frank and open in what they said. They are, as a class, superior men in personality, education, and manner of living. It rapidly became apparent that because the symptoms that I shall describe occur frequently, and fear had been aroused in various ways that they might grow worse, the anxiety of the men was due more to this fear of further and more serious results than to anything known to have occured. In fact, several of those with the most pronounced manifestations said that if that was all, they thought it of comparatively slight consequence. Their fears of bad results had apparently been largely aroused within two years by their interpretation of the opinion of some physicians who had seen some affected men, but who, so far as we could learn, had not actually studied the cases or the men's work carefully, but had somewhat naturally based their advice upon the men's own apprehensions."

A very careful examination was made of nineteen men and Dr. Edsall says that the principal cause of complaint was a temporary blanching and numbness of the fingers when chilled. It occurs almost entirely when the weather is cold, and chiefly in the morning when the men start work and before they get "warmed up." It also tends to recur in cold weather when they are not working or when they plunge their hands in cold water. The condition was described by the men as "annoying," rather than serious. The numbness does not interfere appreciably with the use of their hands. Occasionally they state that it makes them clumsy, slower and less accurate in their work while it lasts.

The men sometimes complain of lameness in the arms, shoulders, or chest, says Dr. Edsall. Two said they slept badly and twitched and turned in their sleep after working hard with the hammer. These two, however, were in poor general condition. Various other symptoms of vague character and significance were elicited in some of the men. I may, however, for brevity's sake state here that neither questioning the men nor careful physical examination showed evidence that the symptoms mentioned or any others outside those in the hands were of any particular significance. They were rather such symptoms as some members of any group of men will always show when doing work, of whatever kind, that is at times hard work and often carried out in constrained positions.

Some of the men said that the sensation was exceedingly disagreeable to them at first, but all except the nervously over-sensitive soon get so accustomed to it that they pay no attention to it. It is in this respect like many other accompaniments of industry, as for instance the noise in many forms of work.

No muscular atrophy was observable. Five men stated that they had earlier had the trouble decidedly, but that it had gradually lessened until it had almost entirely disappeared. They attribute this to having learned to use the tool with greater skill and especially with an easier and less cramped grip. Other experienced workmen told me the older and more skillful men have less bother than the younger and less skilled and attributed this to the same cause and to the fact that the young men use the mallet little in "roughing out," while the older have more familiarity with the mallet and use it a good deal. Mr. Griggs stated also that it is more common in the young men than in the older. He believed this due to the more common use recently of the larger hammer, but the older men state that they use the larger hammers as much as do the younger.

Dr. Edsall says that there are three chief factors that evidently may play a part in producing the symptoms: Cold, constriction, and vibration. He is inclined to believe that the cold elicits the symptoms, rather than produces them. He makes these recommendations:

"It is obvious that certain simple things may be done to attempt to eliminate the trouble. First of all, the shank of the tool, where it is held, could be made larger, so that the grip

need not be so strained. In doing this it would be well to use some substance that would conduct cold or heat poorly, instead of, as at present, intensifying the effect of cold by holding the cold metal. Asbestos suggests itself, and its practicability could be tried. Some of the men have tried rubber hose drawn over the tool, but said it tended to work upward on the tool and choke the action of the hammer. One man, however, said that he soaked the hose in oil, drew it on his tools, and allowed the softened rubber to adhere to the tool in drying and thereby was able to use it successfully. He said that he had earlier had 'dead fingers' but is no longer troubled by them. Asbestos, if practical, would have evident advantages. Some such handle would perhaps serve also to some extent as a shock absorber and thus reduce the possible effects of vibration. It is possible, too, that practicable methods of keeping the tools warm in cold weather could be easily devised and would reduce the discomfort. It is is also to be noted that the practice of controlling the exhaust with the thumb or fingers of the right hand should be discontinued. In the same connection it is to be observed that in some hammers, due either to their construction or to wear, the exhaust leaks out downward along the tool—which it should not do—giving a slight constant blast of cold air on the left hand. This should be obviated. Heating the compressed air has, I believe, been tried, but meets with difficulties, and I do not believe it would be of much value if successfully done.

"Reducing the time spent at any disadvantageous work and shifting to other forms of work is in many kinds of industrial disorders sufficient largely to overcome the trouble. In this instance there is an obvious way of accomplishing this—by requiring the men to use the mallet in suitable parts of the work, especially in 'roughing out.' The operators say they have always preferred that this should be done, especially because compressed air is expensive, but that the men will not do it. The men admit they use the hammer in such work when they do not need to, partly because they get more done, but they say that unless they do the foremen look unfavorably on them and are likely to drop them because they do not work so fast. Evidently adjustments and understandings are needed on both ends here. The men and the operators and their foremen should recognize that the frequent shift to the mallet may go far to obviate the trouble. Dr. Lake's conclusions agree thoroughly with those of Dr. Edsall.

WAR CHEMISTRY

By Henry Howard*

Let us not forget the year of delays and many failures that England and America experienced in developing their numerous high explosive plants, while Germany, with its highly developed dye industry, was able almost over night to adapt its dye plants with their skilled labor to the manufacture of high explosives, so similar are the two lines of manufacture.

There is no doubt that a permanent coal tar dye industry is a matter vitally affecting our national safety in times of peace, because in no other manner can the necessary plant and skilled workers, easily and quickly convertible to use in munition manufacture, be kept available for emergency calls in times of need.

After January, 1915, *potash* importations from Germany practically ceased. Our chemical industry has already succeeded in producing a substantial tonnage of American potash, ranging from the low grade material suitable for fertilizers to that of the greatest purity necessary for use in the manufacture of optical glass such as was formerly made in Jena, Germany, for the use of Zeiss glasses. The importance of this glass at the present time for the manufacture of range finders and high power field glasses can hardly be overestimated. Although the crude potash tonnage now produced is far below the imports before the war, yet very substantial progress is being made. The most important deposit is Searles Lake, San Bernardino county, California, which contains brine testing 4 per cent potassium chloride, from which the potash is recovered and purified.

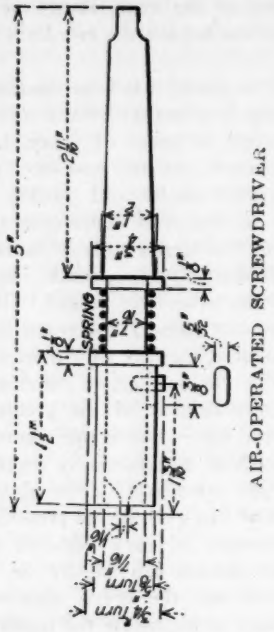
The rapid growth of the American potash industry is shown by the following production figures all calculated on the basis of 100 per cent potash:

Twelve month, 1915—970 tons.
Twelve months, 1916—9720 tons.
First six months, 1917—14,000 tons.
Second six months, 1917—28,000 tons.

*Vice President Merrimac Chemical Company, Boston.

The above figures are from Mr. Hoyt S. Gale, Geological Survey.

At the present time production is probably at the rate of more than 60,000 tons per year, a remarkable showing for an industry only three years old, a result by the way which could not possibly have been attained if price regulation had been practiced in the manner that we have seen in some of our important products. The result is due to almost superhuman efforts of manufacturers to get the benefit of the fabulous prices that potash has been bringing in this market.



COMPRESSED AIR OPERATED SCREW DRIVER

In the packing of munitions most of the covers are fastened on the boxes by wood screws. The operation of driving in the screws occupies a large portion of the time taken to pack a box, and also considerable strength if done by hand. For some time past we have been using the screw driver shown in the cut. It is made with a Morse taper shank, and is used in a No. 4 "Little David" Canadian Ingersoll-Rand drill. The loosely sliding bushing by the thrust of the spring normally overhangs the screw driver a little and, being slotted on the side, is held from dropping off by the little pin as shown. When a screw is to be driven the bushing drops over the head of the screw and when the screw driver is rotated it finds its own place in the nick. *George M. Dick in American Machinist.*

FIG. I

PNEUMATIC TAMPERS LOOSEN FROZEN COAL

By H. L. Hicks

The matter here presented is a little out of season just now, but it may be better to fix it here than to try to keep it over for next season. During the severely cold weather of last winter there developed a novel and interesting adaptation of the pneumatic tie tamper to the breaking up of masses of frozen coal when unloading hopper bottom cars, and excellent results were obtained by this means at coal depots around New York, Chicago and various lake ports when the scheme was introduced. At Chicago the tampers have been applied also

FIG. 2

to picking frozen ore in cars, clearing mill scale from the chutes at steel mills and breaking up frozen scale in gondola cars. At one point the experiment was tried of applying the tamper against the side of a car of soft coal, the vibration thus set up causing the coal to let go and move out of the car with a rush.

For this class of work the tamping machines have been fitted with pointed picks, Fig. 1, in

FIG. 3

FIG. 4

place of the usual tamping bars. The tools are light enough to be conveniently handled regardless of the work or its location. Fig. 2 shows the starting and Fig. 3 the last stage in unloading a solidly frozen carload of buckwheat anthracite after the usual steam thawing has been completed. At this coal dock it was found advantageous to station one man outside the car, Fig. 4, to break up the lumps that clogged the chutes. The general opinion was that the tampers were most effective in frozen bituminous and in the smaller sizes of anthracite coal.

IMPORTANCE OF BINOCULAR VISION FOR AIRMEN

In speaking recently regarding the medical aspect of flying, Sir Watson Cheyne, the famous English doctor, among other interesting things states: "An important thing is the necessity of having true binocular vision, especially when traveling at a great speed, and of having a very rapid connection between the sight and the action; in fact, in selecting pilots, one of the most important points to ascertain is whether the binocular vision is good, and also the time it takes between the aviator seeing and taking action. Very often it has been discovered that one eye is not used at all. Many people are going about with one eye and are not using the binocular vision; that is an extremely dangerous thing. You could not allow a man to enter the Air Service unless you found he had proper binocular vision.

DETAILS OF GAS WARFARE

By S. J. M. Auld*

Not so much is heard of gas warfare at the present time as two years ago, when the first use of that method of attack was made on the Western Front. Gas is, however, used to a tremendous extent, and the amount that has been and is being hurled back and forth in shells and clouds is almost unbelievable. The success of a cloud gas attack depends on thorough preparation beforehand. The attackers must know the country, the layout of the trenches, and the direction and velocity of the wind with certainty. Favorable conditions are limited practically to wind velocities between twelve and fourteen miles per hour, with no upward currents. German gas attacks are made by two regiments of Pioneers, with highly technical officers, including engineers, meteorologists, and chemists.

The first attack was made with chlorine. If a gas attack is to be made with gas clouds, the number of gases available is limited. The gas must be easily compressible, easily made in large quantities, and should be considerably heavier than air. If to this is added the necessity of its being very toxic and of low chemical reactivity, the choice is practically reduced to two gases—chlorine and phosgene. The gas is contained in an ordinary cylinder like that used for oxygen or hydrogen. Pure chlorine did not satisfy quite all the requirements, as it is very active chemically and, therefore, easily absorbed. Pads soaked in solutions of sodium carbonate and thiosulphate were first used in the protective respirators. Later, with the introduction of phosgene, a gas which is very insidious and difficult to protect against sodium phenate was used.

There are so many conditions that have to be fulfilled in connection with the gas cloud that its use is limited. The case is different with gas shells. The gas shells are the most important of all methods of using gas on the Western Front, and are still in course of development. The first use of this method was with the celebrated "tear" shells. A concentration of one part in a million of some of these lachrymators makes the eyes water severely. The original tear shells contained almost pure xylyl bromide or benzyl bromide, made by brominating the higher fractions of coal-tar distillates. Another substance used in shells which simultaneously harasses and seriously injures is dichloro-diethylsulfide (mustard gas). It has no immediate effect on the eyes beyond a slight irritation. After several hours the eyes begin to swell and inflame and practically blister, causing intense pain, the nose discharges freely, and severe coughing and even vomiting ensue. The Germans have also used phenyl-carbilamine chloride, a lachrymator, and diphenychlorarsine, or "sneezing gas." The latter is mixed with high explosive shells or with other gas shells, or with shrapnel. It was intended to make a man sneeze so violently that he is unable to wear his mask. The sneezing gas has, however, not been a very great success.

Up to the present time there has been no material brought out on either side that can be depended upon to penetrate the respirator. The casualties are due to surprise or to lack of training in the use of masks. The mask must be put on and adjusted within six seconds, which requires a considerable amount of preliminary training if it is to be done under field conditions. Both sides are trying to find something the others have not used, and both are trying to find a "colorless, odorless, and invisible" gas that is highly poisonous. It is within the realm of possibility that the war will be finished literally in the chemical laboratory.

*Journal of the Washington Academy of Sciences.

MEASURING AIR VELOCITIES IN MINES

The measurement of the quantity of air passing in a mine airway, by taking velocity readings at a given point in the airway is attended with numerous difficulties that render the results obtained more or less approximate. There are many conditions that make it practically impossible to determine accurately what is the average velocity of the air current in a mine airway.

As is well know, a straight airway that is unobstructed, permitting a uniform flow of air through it, will not give the same velocity readings in close proximity to the sides, top and bottom of the airway as at the center. The friction between the passing air and the rubbing surface of the airway acts to retard the flow of the air in contact with that surface.

BIRAM ANOMOMETER

Again, where bends occur much of the air is deflected from its course in the airway, and crowds the outer curve of the bend where the velocity will be the greatest. Owing to the same cause, the velocity at the inner curve of the bend will be less than at any other point of the airway.

Again, because of a difference in temperature or gaseous condition of the air passing into the mine and that filling the workings and many void and abandoned places, the warmer or lighter air will crowd the roof of the airway, while the cooler or heavier air travels along the floor. This may give a different velocity of the air current at the roof and the floor. The same effect is observed in dips and rises in the airway, where the bulk of the air may crowd the roof or the floor of the passage as the case may be.

An important factor to be considered, in taking measurements of the velocity of air in an airway, is the obstruction that the observer's body presents to the even flow of the air. It is impossible to make any accurate allowance for this obstruction, which always acts to increase the reading of velocity, but not in proportion to the decrease in sectional area by reason of the observer's body.

Not infrequently has it happened that a crafty mine foreman, knowing that his mine was short of air, would affect to be much interested in the readings taken by the mine inspector, hoping that the inspector would not realize that his presence in the airway would give a higher reading, which was his real intent and purpose.

Notwithstanding these practical conditions that affect the accuracy of velocity readings in airways, the prevailing practice is to measure the volume of air passing by taking anemometer readings at a selected point in the airway, where the sectional area has been carefully measured, using for that purpose the Biram anemometer shown in the accompanying figure. In my opinion, the chief point to be considered is that these readings should always be taken at the same point in the airway and under similar conditions, so that the comparison of the readings taken from time to time will be of greater value than if these readings has been taken at different points and under varying conditions.

When taking the velocity readings the observer should stand facing a rib of the airway, with his back against or near the opposite rib. He should hold the anemometer at arm's length, say a foot or so beyond the center of the airway. It is well to take a one-minute reading, say 2 ft. above the bottom and another like reading 2 or 3 ft. below the roof. We would suggest that an attempt to obtain an average reading by moving the anemometer about in the airway, except under particularly favorable conditions, is not generally satisfactory.

While the readings of the anomometer, taken with proper care, are generally accepted in the measurement of air volumes, in common mining practice, when greater accuracy is required engineers employ a Pitot tube, which is an instrument designed to measure the velocity of air in a conduit, as determined by the pressure head producing such velocity. This instrument is not adapted to general use in mines, however, and requires more skill than average mining men possess.—*Coal Age.*

Best results so far obtained in prime movers are a horsepower-hour for 14,000 B.t.u. in large steam turbines, for 10,600 B.t.u. in gas engines, and for 7,700 B.t.u. in Deisel engines.

It has been experimentally determined in England, where illuminating gas is used as motive power for motor buses, that 250 cubic feet of gas is equivalent to one gallon of gasoline.

SAVE AIR

THE SHIPS that you are
BUILDING are
LIFEBOATS for these
MEN and it takes
950,000 RIVETS
TO BUILD a ship like the
KATRINA LUCKENBACH
AND in the meantime, the
U-BOATS are getting about
3 TIMES AS MANY SHIPS
AS are being LAUNCHED;
AND it takes
575,000 RIVETS to build one
DESTROYER to catch a
U-BOAT:
NOW it takes a
MIGHTY SMALL LEAK
TO WASTE enough air
TO RUN A HAMMER

AND WHILE the air
IS LEAKING away, and the
MEN are being SENT HOME
FOR WANT of AIR, and
LOSING their PAY; the
SHIPS are DELAYED and
OUR BOYS OVER THERE
ARE IN DANGER; and
THE U-BOATS never
KNOCK OFF a minute.
DO YOUR PART
STOP THE LEAKS
PUT a WASHER in your
HOSE; take back the
BUSTED HOSE;
MAKE FULL PAY
EVERY WEEK;
FINISH THE SHIPS and
SERVE YOUR COUNTRY.

Poster prepared by direction of Supt. Benson, of the hull construction department, Fore River Shipbuilding Company. It is to be noted that the ratio of ships built to ships sunk has been much improved since the poster was prepared.

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EVERYTHING PNEUMATIC

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THE PNEUMATIC PACEMAKER IN SHIPBUILDING

We need not to be reminded that the most urgent task now pressing so heavily upon the industries of the nation is the building of ships for the transport of troops, munitions and food for the Allies, of whom we are one. The world situation is desperate, and probably our help must determine the result—which is far from suggesting any doubt as to what the result will be. Our millions of men and our vast and various supplies avail nothing on this side of the Atlantic. Differences of speed in the output of ships at this juncture may mean—must mean—the saving or the losing of hundreds of thousands of lives, of billions of material values and months or years more or less of the ghastly struggle.

When striving for speed records a pacemaker is often employed, but in the ship-building race the pacemaker is developing automatically. A pacemaker may work either at the front or at the rear, or, we might say, he may either pull or push. The one goes ahead and challenges the pack to outstrip or at least to keep up with him, but quite as effective pacemaking may often be done, as in this case, at the rear. The slow moving units which happen to be indispensable determine the ultimate advance, and the urging of them along is what tells. In the modern building of ships, as we all know, the most constantly responsible single operation is the riveting. Individual ships now under construction will each require from half a million to far above a million rivets, and the entire work of building can go along to completion no faster than the "driving" of these rivets will permit.

It is gratifying to know that a lively rivalry is current throughout the shipbuilding plants on both sides of the Atlantic for the making of riveting records, these being taken, of course, as indices and guarantees of shipbuilding speed.

It is evident enough that lively riveting, such as now evidently is being done, must make all hands hustle to keep up, and perhaps no better pacemaker could be devised. It is a curious thing that we hear of the pneumatic riveter again as exercising its pacemaking function in the production of the boilers for the ships, the output of the boilershops being determined by the speed of the riveters

and caulkers just as much as that of the shipyards. In the building of the wooden ships the pneumatic tool, the borer, the pin driver, etc., and especially the caulker shows up again as the pacemaker which has done much to hurry up the work.

The pneumatic tools in American shops and yards are doing their bit, in many more ways than here suggested, just as truly as the guns in France.

USING AIR BRAKES WITH JUDGMENT

The matter of coasting, or of running down grades on the surface railways without the use of power has been investigated and found to afford opportunities for quite important savings. The habits of applying and shutting off the motor current, and of using the brake in connection at the precise times to secure the best results, vary considerably with the individual motormen and consequently the consumption of power for trip varies correspondingly.

In a recent issue of the B. R. T. Monthly, William Siebert, superintendent of surface transportation, points out that the schedules on the Brooklyn Rapid Transit system call for 33,400 trips per day. If each motorman on each trip would coast an additional 250 ft., or less than one-twentieth of a mile, or the normal distance between two numbered streets, it would mean a daily saving in power consumed equal to the power it would take to operate one car 8,350,000 ft., or 1581 miles, and from five to ten times this amount could be easily saved.

A very different appreciation of the coasting effect worked out a score of years ago on the Amsterdam Avenue line, Manhattan, running up to Fort George. This line was at that time operating by cable, and there are several quite steep ups and down on the surface. When the cars were running down hill if the grip on the cable was maintained a considerable forward pull was given to the cable and much power was saved. The motormen in this case were very fond of coasting and they would release the grip and check the speed when necessary by using the brake. Not only was much power thus lost but the cars ran ahead of their schedule time, so that it was necessary to issue stringent orders prohibiting coasting.

NAVAL CONSULTING BOARD ON PULVERIZED FUEL

The following is a brief abstract of a report to the President of the U. S. Shipping Board prepared by the Fuel and Fuel Handling Committee of the Naval Consulting Board:

The art of pulverizing and burning coal as a powder has passed beyond the experimental stage in several of the arts. It is extensively employed for smelting, for burning cement and for generating steam.

From evidence placed before us pulverized coal is a smokeless fuel, a fact of considerable military importance.

By a simple and immediate adjustment of the burners, powdered coal as a fuel may be made to emit dense clouds of smoke to serve as a screen, another fact of military importance.

In an emergency the ship's boilers may be rapidly forced, thereby increasing the steam supply and the speed of the vessel. This is a fact of military importance.

A great reduction in the fire-room force is effected over using solid coal. This saving in man power has military value.

The supply of fuel oil in the United States is limited, and as a means of conserving fuel oil for naval vessels equipped to burn oil exclusively the Consulting Board feels justified in encouraging the use of powdered coal as a fuel for merchant ships, and we therefore earnestly recommend that the Emergency Fleet Corporation authorize the preparation of the necessary plans and drawings for such an installation upon such ships, and that a shore installation be made of such equipment to determine as well as may be the value of such an installation on board ship. Such shore installation can be set up and tested at the Annapolis Experiment Station, Annapolis.

A ship equipped with pulverizing equipment should, in the opinion of the Naval Consulting Board, be expected to take on coal in any port of any kind available and by the ordinary methods. In Atlantic ports this will be run-of-mine bituminous of high volatile and of high grade, sometimes dry and dusty and at other times quite wet.

Such coal on board ship, following shore practice, would then pass through the following processes:

Crushing in power rolls, and delivering to a storage bin.

Drying if found essential to remove the moisture prior to pulverizing, delivering to a second storage bin.

Extraction of iron particles. This being advised to save damage to the pulverizing mill. A magnetic separator is commonly used for this purpose.

Pulverizing, either in Fuller or Raymond mills or their equivalent, then storing in a third storage bin.

Mixing with air, feeding to furnace and burning.

After delivery of the raw coal to crushers the fuel will be handled by conveyors or spouts. All storage bins, conveyors and spouts must be constructed and maintained dust-tight as a means of preventing explosions, and possibly such may have to be made of non-corrosive material.

The Naval Consulting Board is at your service, and if it be your pleasure to proceed in the preparation of designs, estimates and specifications, we shall be honored by your seeking our aid in the solution of this important problem.

NEW BOOK

Powdered Coal as a Fuel by C. F. Herington, New York, D. Van Nostrand Company, 220 pages, 6 by 9 inches, 84 illustrations. $3.00 (net).

To day when powered fuel is being used so extensively for economical and other reasons, and when so many are seeking information upon the subject, this book comes opportunely. What it purposes to do is done in a business way and with satisfactory completeness. The principles involved and the conditions essential to success are discussed and then a large portion of the book is given up to descriptions in great variety of actual installations with full details, costs, etc. A bibliography of 12 pages will be of value to those who wish to know all that is available on the subject.

REPAIRING TUNNEL LININGS WITH GUNITE

The linings of two tunnels on the Northern Pacific which had become seriously disintegrated through the combined action of water, locomotive gases and frost, were repaired recently by giving them a coating of "gunite," a cement mortar, applied by means of the cement gun. Owing to the fact that the entire replacement of these linings would have been both expensive and dangerous, the success of the plan adopted, which necessitated the application of only a relatively thin coating over the old lining, is of special interest. Because of dense traffic and bad atmospheric conditions in one of the tunnels, the work was done under rather trying circumstances.

The tunnels in question are the Bozeman tunnel, located about half-way between Livingston, Mont., and Bozeman, and the Mullan tunnel, about 20 miles west of Helena, Mont., the former at the summit of the Gallatin range and the latter at the summit of the Continental divide. The former presented the most serious difficulties and is treated in greater detail in the following description:

The Bozeman tunnel is 3,650 ft. long, built for single track, and was lined some 20 years ago with brick and concrete. About six years ago the approaches from both the east and the west were reconstructed to reduce the grade to 1.8 per cent. compensated, these grades extending into the tunnel at both ends to a summit located about 900 ft. from the west portal. Double track was extended up the hill to the portals at the same time.

Both approach grades are operated with helper engines, and as the maximum grade extends into the tunnel, the pushers must follow the trains through in each direction, dropping back after the train passes the summit. This operating arrangement, coupled with the location of the summit within the portals, results in the continual presence of dense smoke. The tunnel is very wet, enough water flowing out of the east portal to supply a water station at Muir, located a sufficient distance down the grade to permit a gravity flow into the roadside tank. This water, coming through the lining and subject to the action of the flue gases and the frost in winter, resulted in the disintegration of both the brick work and and the concrete, the latter suffering the worst. At one time 200 weep holes were installed at various points in the tunnel to concentrate the flow and reduce the seepage through the lining, but this did not reduce the progress of disintegration materially.

Similar conditions obtained at the Mullan tunnel, which is 3,900 ft. long and is lined with a brick arch and concrete side walls. The disintegration in this tunnel, however, was not

so severe. The summit of the grade line is outside the tunnel, and because of this and the fact that a ventilating plant is in operation, the atmospheric conditions within the tunnel are much better.

After a study of the situation at both of these points a contract was awarded to the Cement Gun Construction Company, Chicago, to repair the linings with an application of gunite. The contractor was paid on a quantity basis, determined by place measurements, the engineer in charge determining the extent and thickness of the coating to be applied from an inspection of the condition of the lining and observation of the results secured as the coating of gunite was applied. This coating was put on to a thickness of 1½ to 5 in. No attempt was made to fill the deeper holes, some of which had a total depth of over one foot. Wherever the lining appeared to be in good condition the coating was omitted. Usually in cases where portions of the first course of brick had disappeared no repair work was done wherever investigations showed that the course underneath was in good condition.

The contractor furnished the plant, labor and superintendent. The railway supplied the materials and the work-train service. The plant consisted of a box car containing a gas engine, belt-connected to a 10-in. by 12-in. single-cylinder air compressor, which supplied air to a cement gun machine placed in an adjacent car, which also contained the materials for making the cement mortar. The roofs of these cars were used as platforms on which the men worked while cleaning the surface of the lining, attaching the reinforcement or applying the stream of gunite. The mixture in the cement gun was transmitted to the nozzle through a 1¾-in. hose. The nozzle was of 1-in. caliber and was also attached to a ¾-in. hose supplying water for washing. It was necessary to operate the air compressor at a rate that compressed about 125 to 130 cu. ft. of free air per minute, in order to maintain the necessary pressure of 30 lb. per sq. in. at the nozzle.

The crew for operating the plant for one shift consisted of one engineer for the compressor, one man operating the cement gun, two or three men mixing the materials, one man feeding the gun, one nozzle operator and one nozzle helper. The materials consisted of cement and sand, the latter secured from Logan, Mont., and being required to pass a ⅜-in. screen. The sand and cement were mixed in the proportions of 1 to 3½, or 9 sacks of cement to 30 cu. ft. of sand. The cement used in the Bozeman tunnel totaled 3,700 sacks and that in the Mullan tunnel 3,400 sacks. The mixture of the material remaining in place in the coating is of course much richer than that indicated above because of the rebound of a large portion of the pebbles. This rebound was greater on the brick surface than on the concrete. One sack of cement on an average covered an area of 2¾ to 3 sq. yd. to a thickness of 1 in.

Before applying the mortar ½-in. lag screws 4 in. long were set in holes drilled with pneumatic hammers, and No. 28 American Steel & Wire Company triangular mesh was attached to these screws in strips of sufficient length to cover as great a width of the arch as it was desired to coat. In general the gunite was applied to a thickness that was deemed sufficient to stop the leakage. Where large areas were wet it was found possible to apply the material around the edges first, gradually reducing the area until finally the water was closed off. In some cases the installing of additional drain pipes resulted in unwatering portions of the lining so that no protection was required. In a few places near the bottoms of the side walls concrete was applied by hand where it could be done readily rather than to shoot it in place with the gun. In some cases two layers of gunite were applied, but on the whole one coating was found sufficient. In the Mullan tunnel several large holes in the arch were repaired by building form work into the holes against which the gunite was applied, the forms remaining permanently in place. As the new surface was adequately reinforced the eventual decay of the form work was of no concern.

The work on the Mullan tunnel was done first and required five months' time. When this was completed the plant and crew were moved to the Bozeman tunnel. Here the work was hampered both by the density of traffic and by the continual presence of smoke. Counting the pusher movements, there were as many as 65 train movements through the tunnel in 24 hours. The work train operated under No. 19 order and was always under the protection of the staff system in effect between the stations at each portal of the tunnel. Both night

and day shifts were employed, but the total number of hours of actual work in the tunnel in each 24 was relatively small because of the short periods that the work train could remain in the tunnel and the long waits between the time. Atmospheric conditions were bad, not only because of the slow escape of the smoke produced by the moving trains, but also because of the presence of the locomotive attached to the work train. The workmen suffered severe discomforts both because of difficulty in breathing and the fact that, with the presence of both water and smoke, they quickly became covered with a black slime. Furthermore, the smoke made it very difficult to illuminate the work, and it was necessary to rely upon bells almost entirely for transmitting signals between the men.

While the work on the Bozeman tunnel was in progress the compressor car caught fire and before this could be extinguished the machinery had been ruined. For the remaining work the air was supplied from a temporary plant rigged up from another compressor operated by a steam engine receiving steam from the work train locomotive. Because of the combination of adverse conditions the work was very trying for the entire force, and progress at times was extremely slow.

The repair of both of the tunnels was under the direction of A. M. Burt, chief engineer maintenance of way, Northern Pacific, and F. J. Taylor, division engineer at Livingston, Montana. A. F. Eckhardt was the superintendent for the contractor.

THE GIBRALTAR TUNNEL

The Gibraltar Tunnel is one of those perennial schemes which periodically exercise the imagination of engineers. It is true that the proposal to construct a tunnel under the Straits of Gibraltar has not cropped up quite so frequently as some other great engineering projects have done, and, in fact, the only occasion on which it has been considered seriously was in 1898, when the French engineer, Berlier, drew up his plans. The idea was at that time, however, regarded as impracticable.

M. Henri Bressler has now endeavored to revive interest in the scheme, and at the last meeting of the session of the French Civil Engineers, he read a paper on the subject. He first of all pointed out what a powerful factor such a tunnel would be in the development of the port of Dakar in particular, and of Spain and Morocco in general. There would be a direct line from Paris to Senegal, and the journey from Paris to St. Louis could be accomplished in three days. If connected up with the great Trans-African Railway, contemplated by the British, it would be possible to travel from London to the Cape in a week, assuming, of course, the existence of the Channel Tunnel, as well as the Gibraltar Tunnel.

The separation of Europe from Africa at this point was due to some terrible cataclysm in a remote geological age. The depth of water is, of course, in some places very great, and the sea bottom is extremely rugged and irregular. However, if the site were carefully chosen, it would not be necessary to go below 840 m. (2755 ft.). The point of departure on the Spanish side would be Tarifa, and on the Morocco side there would be a choice of two points, each of which has its own special advantages. The total length of the tunnel would be about 25 kiloms., and a train travelling at 80 kiloms. (50 miles) would traverse it in 20 minutes.

In estimating the cost of construction, the author starts with the figure of 4415f., which is the average cost per metre of the four principal Alpine tunnels: Arlberg, Mont-Cenis, Gothard and Simplon. Taking this figure as a basis, it is estimated that the cost of a marine tunnel would be a little more than double the cost per metre of the land tunnels above named, say, 10,000f. per metre. Assuming the total length of 25 kiloms., this would mean 250,000,000f., to which must be added a further 110,000,000f. for improvements in the port of Dakar, making a total of 360,000,000f.—*The Engineer.*

BOTTLED LIQUEFIED GAS IN THE TRENCHES

The following from "somewhere in France," appears in the daily papers: What is probably a new German liquefied gas was projected this morning against the Picardy front where American troops are fighting. The gas, in its fluid form, is contained in glass bottles. On bursting they give off some substance from which heavy, white fumes, transparent in texture, continue to arise for five minutes. No detonation was heard as the bottles were hurled through the air and apparently they were thrown by a spring. The gas caused

nausea, sneezing and coughing but did not otherwise harm any of the Americans.

NOTES

Frost will penetrate to a greater depth in gravel than in clay when both are saturated with water, for water is a better heat conductor than are the minerals that compose soils. In a New England town last winter frost penetrated to a depth of 6½ ft. in gravel and only 3½ ft. in clay.

Soot burns very slowly in the furnace gases because the oxygen is greatly rarefied, the gases containing only a few per cent. of free oxygen; it burns rapidly in the bomb calorimeter or in mixture with potassium chlorate because it is surrounded with highly concentrated oxygen ready to combine with it.—*Bureau of Mines Bulletin No. 135.*

Louisiana, as might be supposed from its geographical position, receiving, as it does, the delta sedimentation from a great continental drainage basin, possesses a remarkable variety of clays. Almost every sort required in the industrial and decorative arts is to be found in that State. The U. S. Geological Survey has recently issued bulletin 660-E, dealing with these resources.

Fertilizers of all kinds will henceforth be subjected to Government control through the operation of an executive order for licensing the importation, manufacture, storage, and distribution of sulphuric acid, sulphur, phosphate rock, acid phosphate, basic slag, sodium nitrate, ammonium sulphate, cyanimid, calcium nitrate, potash salts, cement dust, blast-furnace dust, wood ashes, and all other fertilizer ingredients.

A round, smooth hole in the side of a granite mountain about nine miles out from Mexico City, is locally known by a term which signifies "Pluto's safety valve." The hole is about nine inches in diameter at the opening, which is polished in a manner which suggests human workmanship. That man had nothing to do with drilling or polishing the hole will be readily surmised when it is known that it has occasionally emitted hot air and smoke for a known period of not less than 300 years.

Obviously, mixing is an important factor in combustion. Merely an excess of air in the furnace is not enough; the air must be supplied as near to the surface of the fuel bed as practicable, and be thoroughly mixed with the combustible matter in order that the combustion may be completed in a short time and a small combustion space made effective.—*Bureau of Mines Bulletin No. 135.*

Fuel Administrator Garfield has authorized a survey to be made to determine the practicability of establishing central generating stations at anthracite mine centers and transmitting electrical energy to industrial centers at New York and other seaboard cities instead of transporting coal. If feasible, the project will be financed by the government.

It is planned to link up this system of transmission lines with all vital centers in addition to New York within a radius of 150 miles. Low grade coals will probably be used.

An item in the Swiss engineering journal, *Schweizerische Bauzeitung,* tells of the breakage of a cylinder head due to an unusual cause, bad lubricating oil. The rear cylinder cover of a 500-hp. uniflow steam engine was forced out during operation but not by waterhammer, the usual cause. The cause of the break was found to be in the bad quality of the cylinder oil (tar oil). The deposit from this very thick oil, which also contained various mechanical impurities, accumulated on the piston and cylinder-head surfaces in a continually thickening crust which finally filled the entire clearance space at the back end of the cylinder and in time began to strike, compressing the substance more and more solidly and finally forcing the cylinder head out.

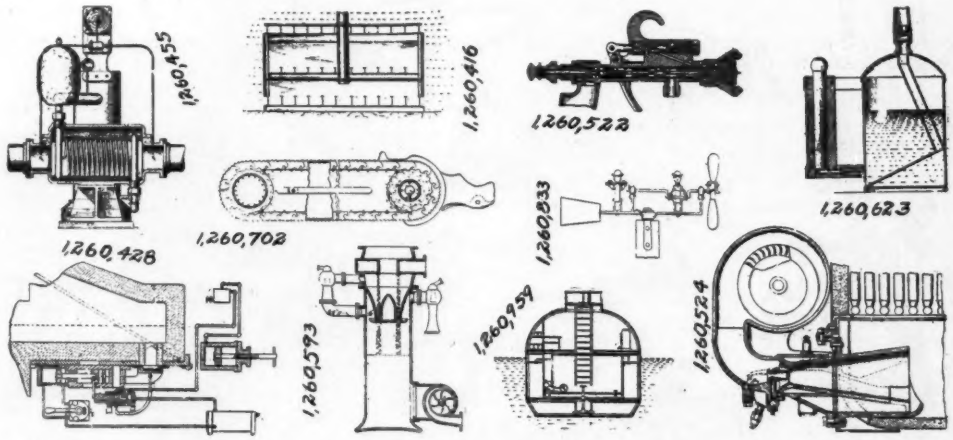
This country has drafted its young men for the greatest sacrifice that a man can make. Is there any logical reason why all able-bodied males should not be compelled to do at least eight hours work every working day until this war ceases, for which they will be paid far beyond what the man who makes the greatest sacrifice is paid? The enemy recognizes no restrictions of labor or time, so that the least that those of us who are at home can do is to stay on the job and put our hearts into it.—*George S. Rice to American Institute of Mining Engineers.*

A new way to make iron or steel rust-proof is claimed in a patent (U. S. 1,248,053) issued to William H. Allen of Detroit. Vapors containing phosphorus compounds are made use of. The process consists in subjecting articles of iron and steel, properly cleaned by pickling or sand blast, to the fumes or vapors of phosphorus pentoxide or anhydride, together with some aqueous vapor until surfaces of basic phosphates of iron are produced. These vapors may be produced in any desired manner, the preferred process consisting in subjecting a mixture of ground phosphate rock, coke and sand to a strong current in an electric furnace. The liberated phosphorus immediately changes to P_2O_5, and these fumes are drawn into the processing chamber by means of a suction fan. The fumes may be first passed through a dust chamber.

A saving of 25 per cent. in ammonia consumption by ice and refrigeration plants will mean several million pounds annually for munitions. A pound of ammonia will make 20 hand grenades.

The year 1917 holds the record for production of Portland cement, a total of approximately 93,554,000 barrels having been manufactured, an excess over the former high production of 1913 of nearly 1,500,000 barrels.

Lifting magnets are used successfully in recovering iron and steel objects that had been sunk in the water. Recently a Cutler-Hammer type of magnet was applied to lift 420 tons of pig-iron from a wrecked barge in the Tennessee river.



PNEUMATIC PATENTS MARCH 26

LATEST U. S. PATENTS

Full specifications and drawings of any patent may be obtained by sending five cents (not stamps) to the Commissioner of Patents, Washington, D. C.

MARCH 26

1,260,416. TUNNEL CONSTRUCTION. Duncan D. McBean, New York, N. Y.

1. A means for preparing foundations for tunnel sections which comprises an air and water-tight open bottomed structure of slightly greater length than width and of the dimensions of a tunnel section, a horizontal and removable partition therein which forms a chamber beneath it for compressed air, and ballast tanks above it, and means for permitting access to the compressed air chamber, whereby a trench may be prepared under the structure when lowered to the bottom with its longer axis, transverse to the line of tunnel, of greater width than the tunnel to be laid therein.

1,260,428. PROCESS AND APPARATUS FOR CONTROLLING THE FLOW OF GLASS. William J. Miller, Swissvale borough, Pa.

1,260,445. METER FOR MEASURING GAS. Dorsey R. Potter, Clarksburg, W. V.

1,260,522. AIR-BRUSH. Thomas A. De Vilbiss and Godfrey Mueller, Toledo, Ohio.

1,260,524. INSTANTANEOUS-IGNITION MECHANISM FOR FUEL-OIL ATOMIZERS. Abner Doble, Detroit, Mich.

1,260,593. CONDENSING APPARATUS. Robert Suczek, Philadelphia, Pa.

1. The combination in a jet condenser, of a condensing chamber and a water collecting chamber, a diffuser forming a connection between said chambers and maintaining them independent when conducting cooling water, and means for extracting elastic fluid from said condensing chamber and delivering it at higher pressure into the elastic fluid above the liquid in said collecting chamber through a passage independent of said diffuser.

1,260,623. COMPRESSED-AIR OILER. Edwin E. Baker and Guy H. Snavely, Willows, Cal.

1,260,701-2. PNEUMATICALLY - OPERATED CHAIN SAW. Charles J. Olson, Muskegon, Mich.

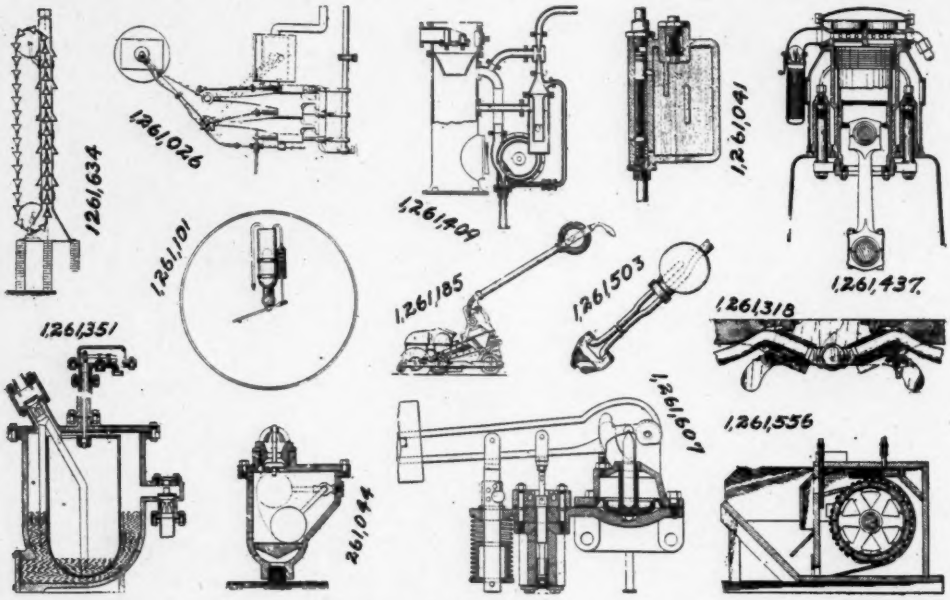
1,260,833. WIND-OPERATED TOY. Harvey Thatcher, Maroa, Ill.
1,260,959. SUBMERSIBLE APPARATUS. Vittorio Boscavilla, San Francisco, Cal.

APRIL 2

1,261,011. PNEUMATIC SHOCK-ABSORBER. Samuel R. Cook, San Jose, Cal.
1,261,026. VACUUM-LIFT. Ernest N. Hogue, Wilkinsburg, Pa.
1,261,041. AIR-COMPRESSOR SYSTEM. Carl E. L. Lipman, Beloit, Wis.
1,261,044. AIR-VALVE. Mark McCracken, Portland, Oreg.
1,261,101. SPRAYING APPARATUS. Joseph T. Clark, De Graff, Minn.
1,261,185. PUMP FOR VACUUM-CLEANERS. Horace H. Taylor and Leonard A. Moberry, Oakland, Cal.
1,261,634. APPARATUS FOR DEVELOPING POWER. Leonard Slingland, Paterson, N. J. 1. An apparatus for developing power comprising a vertical column having air inlets at vertically spaced points, and power developing means in said column driven by an upwardly moving current of air therethrough.

APRIL 9

1,261,753. FAN. Per August Anderson, New York, N. Y.
1,261,780. MILKING APPARATUS. Laurits D.nesen, Minneapolis, Minn.
1,261,806-7. BLOWER. John E. Greenawalt, Denver, Colo.
1,261,940. APPARATUS FOR THE PRODUCTION OF PRESSURE GAS-VAPOR. Charles Edmund Johnson, Hobart, Tasmania, Australia.

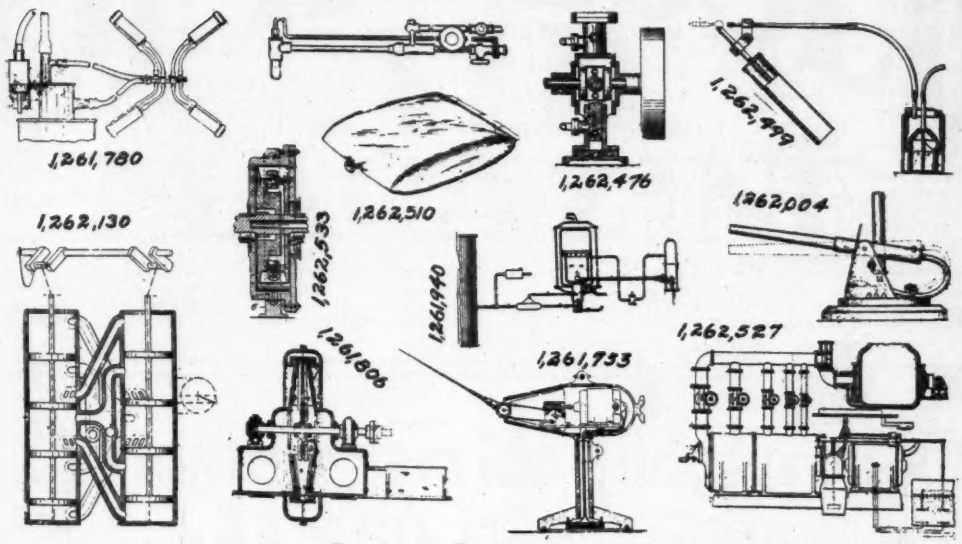


PNEUMATIC PATENTS APRIL 2

1,261,318. AIR-LINE-HOSE-COUPLING DEVICE. Frank M. Thomas, Piggott, Ark.
1,261,351. APPARATUS FOR ELEVATING OR LIFTING ACIDS OR THE LIKE. Thomas Bradbear, Sparkbrook, Birmingham, England. 1. In an apparatus for elevating or lifting acids or the like, the combination of a tank sealed in an airtight manner; an open-topped float therein; means for admitting acid to the tank and exterior of the float and later to the interior of the float so as to sink the float; outlet pipes and valves to the tank and interior of the float; and means controlled by the float for admitting compressed air to the interior of the tank when the float sinks; for the purpose specified and substantially as set forth.
1,261,409. SURFACE AND JET CONDENSER. Maurice Leblanc, Val-sur-Seine, Croissy, France.
1,261,437. AIR-COMPRESSOR. William Reavell and Edwin Walter Jones, Ipswich, England.
1,261,503. ATOMIZER. Walter W. Figgis, Brooklyn, N. Y.
1,261,556. PROCESS FOR AERATING LIQUID. Frederick B. Kollberg, Bisbee, Ariz., and Max Kraut, Los Angeles, Cal.
1,261,607. REGULATOR FOR COMPRESSOR-UNLOADERS. Arthur E. Peters, Easton, Pa.
1,262,004. PNEUMATIC GUN. Walter F. Beachy, Chicago, Ill.
1,262,130. VALVELESS APPARATUS COMPRISING PISTONS HAVING AN ALTERNATING RECTILINEAR MOTION FOR DRAWING AND DELIVERING FLUIDS. Henri Steven, Montefurado, Spain.
1,262,239. PNEUMATIC VALVE. Joseph N. Newsom, St. Louis, Mo.
1,262,351. CUTTING AND WELDING TORCH. Allan H. Jones and Charles H. MacNichols, Oakland, Cal.
1,262,476. AIR-COMPRESSOR. Henry Fleming, Brooklyn, N. Y.
1,262,499. HAND BLAST-TORCH. Bert M. Howell, Newton, Ill.
1,262,510. PNEUMATIC PILLOW. Ida Kelly, Waco, Texas.
1,262,527. CENTRIFUGAL COMPRESSOR. Louis C. Loewenstein, Lynn, Mass.
1,262,533. ROTARY COMPRESSOR. George C. McFarlane, Denver, Colo.

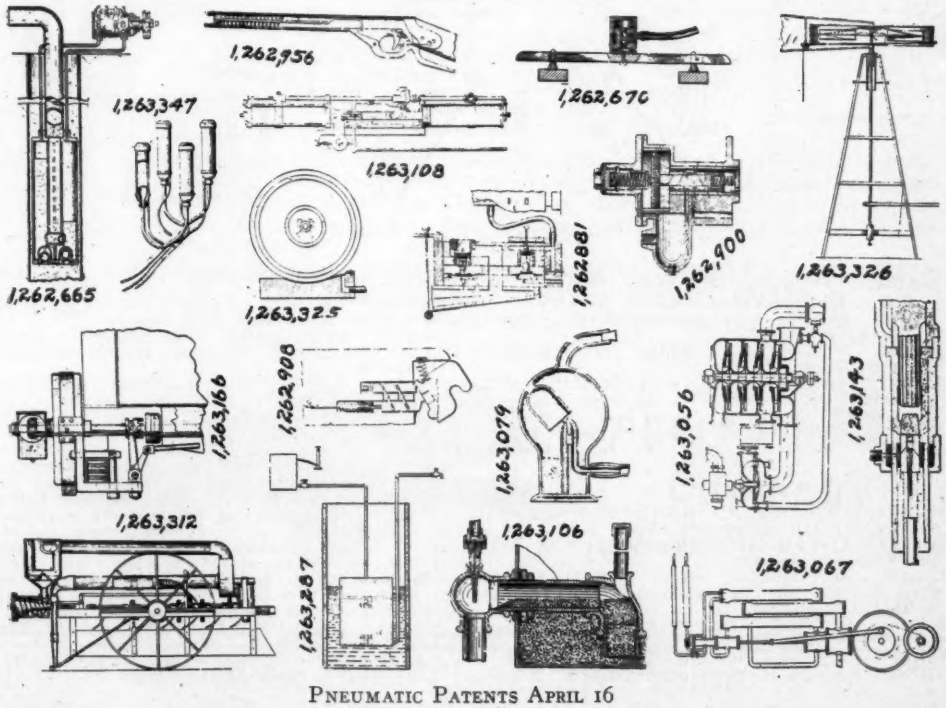
APRIL 16

1,262,665. PUMP. Harry K. Hedges, Los Angeles, Cal.
1,262,667. AIR-COMPRESSOR CONTROL. Ebenezer Hill, Norwalk, Conn.



PNEUMATIC PATENTS APRIL 9

1,262,670. PNEUMATIC TONE - PRODUCER. Robert Hope-Jones, deceased, North Tonawanda, N. Y., by Cecil Hope-Jones, temporary administratrix, North Tonawanda, N. Y.
1,262,881. PIANO-PLAYER. Eugene C. Wamelink, Cleveland, Ohio.
1,262,883. COMBINED AUTOMATIC AND STRAIGHT AIR VALVE MECHANISM. Frank H. Weimer, Nogales, Ariz.
1,262,900. COMBINED AUTOMATIC AND STRAIGHT AIR VALVE MECHANISM. John A. Adams, Nogales, Ariz.
1,262,908. STEAM, ELECTRIC, AND COMPRESSED-AIR CAR-COUPLING. Carlos C. Ayres, Detroit, Mich.
1,262,956. POP-GUN. Arthur A. Karcher, Chicago, Ill.
1,263,056. OPERATION OF CENTRIFUGAL-COMPRESSOR PLANTS. Benjamin Graemiger, Zurich, Switzerland.
1,263,079. INHALING APPARATUS. Leon S. Leon, Chicago, Ill.
1,263,106. VACCUM - SANDER. Charles A. Pratte, Denver, Colo.



PNEUMATIC PATENTS APRIL 16

1,263,108. FLUID-OPERATED MOTOR. Horatio C. Randall, San Francisco, Cal.

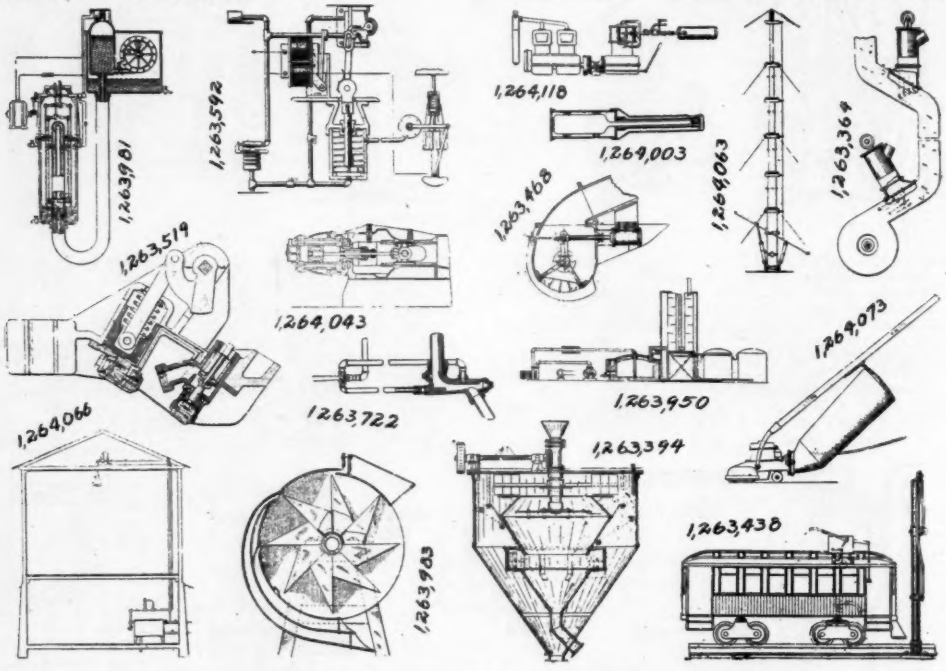
1,263,143. ROCK-DRILL. Thomas E. Sturtevant, Dover, N. J.

1,263,166. AIR-PUMP. Clinton L. Walker, Piedmont, Cal.

1,263,287. WATER - PRESSURE SYSTEM. James S. Ragains, Ottumwa, Iowa.

1. In a water pressure system, a tank adapted to be arranged in a body of water, said tank comprising a floating air chamber and a communicating water chamber, the latter having valves permitting the ingress of water and air and closing against the egress of the water, means for supplying air under pressure to the air compartment, and a draw-off pipe connected to the water compartment.

1,263,299. VACUUM-CLEANER. Emil F. Wemhoener, St. Louis, Mo.



PNEUMATIC PATENTS APRIL 23

1,263,312. BOLL - WEEVIL - DESTROYING MACHINE. Thomas H. Diserens, Dallas, and Frank C. McKay, Celina, Tex.

1,263,325. FLUID - DRIVEN MOTOR. Emil Klahn, Livingston, N. J.

1,263,326. WINDMILL. Anton L. Koester, Gorham, Kans.

1,263,347. TEAT-CUP CLAW FOR MILKING APPARATUS. John G. G. Eklundh, Columbus, Ohio.

1,263,354. PNEUMATIC - DIAPHRAGM FOLLOWER. Robert A. Gally, Cincinnati, Ohio.

APRIL 23

1,263,364. PNEUMATIC GRAIN-ELEVATOR. George Bernert, Milwaukee, Wis.

1,263,394. AIR-SEPARATOR. George S. Emerick, Philadelphia, Pa.

1,263,438. AUTOMATIC STOP MECHANISM FOR CARS. William E. Lawn and James A. Ryan, Rochester, N. Y.

1,263,468. SUCTION DREDGE-HEAD. John Reid, New York, N. Y.

1,263,519. AUTOMATIC TRAIN-PIPE COUPLING. Thomas R. Brown, Sparkill, N. Y.

1,263,556. PNEUMATIC ACTION FOR PLAYER-PIANOS. Mathew Hilgert, New York, N. Y.

1,263,592. TRAIN-STOPPING MEANS. William Brooks Murray, Danville, Ill.

1,263,722. LOCOMOTIVE SANDING DEVICE. William H. White, Roanoke, Va.

1,263,950. CONCENTRATION AND PURIFICATION OF SLUDGE ACID. William A. Slater, Fort Worth, Tex.

1,263,981. POWER SYSTEM AND PUMP. James Wilkinson, Schenectady, N. Y.

1,263,983. AIR-OPERATED MOTOR. Charles H. Winne, Troy, N. Y.

1,264,003. CARTRIDGE CONTAINING COMPRESSED OR LIQUEFIED GAS FOR INFLATING LIFE - PRESERVING BELTS, PNEUMATIC TIRES, AND OTHER PURPOSES. William Gould Brokaw, Paris, France.

1,264,043. AMMONIA-COMPRESSOR. George Ferguson, Apeldoorn, Netherlands.

1,264,063. PNEUMATIC TELESCOPIC MAST AND ITS APPLICATIONS. Marcel Guichard, Paris, France.

1,264,066. HOUSE-VENTILATING AND FIRE-EXTINGUISHING SYSTEM. Andrew B. Hamil, Andrew O. Vensel, and Frank S. Bergstrom, Ray, Ariz.

1. A ventilating and fire extinguishing system including compressed air conducting means, water conducting means, means to cut off the compressed air conducting means, means to cut off the water conducting means, means including a fusible member to normally hold the air cut off means in open position and the water cut off means in closed position, and fluid pressure actuated means to close the said air cut off means and open the said water cut off means, when said fusible element is fused.

1,264,073. SUCTION-SWEEPER. Howard Earl Hoover, Chicago, Ill.

1,264,118. COMPRESSED-AIR AUTO-STARTER. Neal T. Nash, Hinton, Iowa.